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Appendix C

Calculation of Groundwater Risk-Based Concentrations

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Calculation of Groundwater Risk-Based Concentrations

C.1 INTRODUCTION

The purpose of this appendix is to describe the methodology and approach for development of groundwater risk-based concentrations (RBCs) that will be used to develop a set of waste soil concentration limits based on meeting the groundwater remedial action objectives (RAOs) in groundwater downgradient of the Idaho National Engineering and Environmental Laboratory (INEEL) *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) Disposal Facility (ICDF). RBCs were developed for the contaminants in the design inventory, based on a residential exposure scenario.

C.2 EXPOSURE SCENARIO

Adult and child residents located downgradient of the ICDF could potentially be exposed to site-related constituents in groundwater through ingestion, dermal contact, and inhalation of volatiles during showering or other household activities. The residential exposure scenario assumes a groundwater ingestion rate of 2 liters per day for adults and 1 liter per day for children, and an exposure frequency of 350 days per year, over a 30 year duration (6 years for a child plus 24 years for an adult).

RBCs for the residential exposure scenario are based on a target excess lifetime cancer risk of 1×10^{-4} for carcinogens or a hazard quotient of 1 for noncarcinogens.

C.3 EXPOSURE ASSUMPTIONS

Exposure assumptions for development of groundwater RBCs for the residential scenario are summarized in Table C-1 at the end of this appendix.

C.3.1 Equations for Non-Radiological Groundwater Risk-Based Concentrations

Groundwater RBCs were calculated in accordance with U.S. Environmental Protection Agency (EPA) guidance (EPA 1991). The following subsections provide the equations used to calculate the RBCs for carcinogens and noncarcinogens.

C.3.1.1 Noncarcinogens

Equation (C-1) was used to calculate the groundwater RBCs for noncarcinogenic chemicals:

$$RBC(\text{mg/L}) = \frac{\text{THI} \times \text{ATN} \times 365 \text{ days/year}}{EF \times \left[\left(\frac{1}{RfD_o} \times IR_{adj} \right) + \left(\frac{1}{RfD_d} \times CF \times SA_{adj} \times Kp \right) + \left(\frac{1}{RfD_i} \times INH_{adj} \times VF \right) \right]} \quad (\text{C-1})$$

C.3.1.2 Carcinogens

Equation (C-2) was used to calculate the groundwater RBCs for carcinogenic chemicals:

$$RBC(\text{mg/L}) = \frac{TR \times ATC \times 365 \text{ days/year}}{EF \times \left[\left[SF_o \times IR_{adj} \right] + \left[SF_d \times CF \times SA_{adj} \times Kp \right] + \left[SF_i \times INH_{adj} \times VF \right] \right]} \quad (\text{C-2})$$

where

$$IR_{adj} = \left(\frac{IR_a \times ED_a}{BW_a} \right) + \left(\frac{IR_c \times ED_c}{BW_c} \right)$$

and

$$SA_{adj} = \left(\frac{SA_a \times ET_a \times ED_a}{BW_a} \right) + \left(\frac{SA_c \times ET_c \times ED_c}{BW_c} \right)$$

and

$$INH_{adj} = \left(\frac{INH_a \times ED_a}{BW_a} \right) + \left(\frac{INH_c \times ED_c}{BW_c} \right).$$

Chemical-specific dermal permeability coefficients (Kps) are derived from the *Dermal Exposure Assessment: Principles and Applications* and the *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance Dermal Risk Assessment Interim Guidance* (EPA 1992; EPA 1998).

Volatile constituents considered for the inhalation pathway are operationally defined as those constituents with a Henry's Law Constant greater than $10^5 \text{ atm}\cdot\text{m}^3/\text{mole}$ and a molecular weight less than 200 grams per mole (EPA 1991).

C.3.2 Equations for Radiological Groundwater Risk-Based Concentrations

Groundwater RBCs were calculated in accordance with EPA guidance (EPA 1991). Only the carcinogenic effects of radionuclides are considered for this evaluation. The following subsections provide the equations used to calculate the RBCs for radiological parameters.

C.3.2.1 Carcinogens

Equation (C-3) was used to calculate the groundwater RBCs for carcinogenic chemicals:

$$RBC(\text{pCi/L}) = \frac{TR}{EF \times \left[\left[SF_o \times IR_{adj} \right] + \left[SF_o \times CF \times SA_{adj} \times Kp \right] \right]} \quad (\text{C-3})$$

where

$$IR_{adj} = (IR_a \times ED_a) + (IR_c \times ED_c)$$

and

$$SA_{adj} = (SA_a \times ET_a \times ED_a) + (SA_c \times ET_c \times ED_c).$$

Chemical-specific dermal permeability coefficients (Kps) for radiological parameters were not available. However, radiological constituents were predicted to behave similarly to metals in groundwater, therefore Kp values for metals were used as surrogate values. Kp values for metals are derived from the *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance Dermal Risk Assessment Interim Guidance* (EPA 1998).

None of the radiological parameters were identified as volatile constituents, therefore the inhalation pathway was not evaluated. Although tritium and radon may be present in household water the amounts inhaled during showering and other water uses is only a fraction of the amounts ingested by drinking of water.

C.4 Toxicity Values

The primary source of toxicity values is the EPA's Integrated Risk Information System (IRIS) database. If a toxicity value is not available from IRIS, then Health Effects Assessment Summary Tables (HEAST) were used. Toxicity values (i.e., cancer slope factors, inhalation slope factors, oral reference doses, and inhalation reference doses) used to calculate the groundwater RBCs are presented at the end of this appendix in Table C-2 (for non-radiological parameters) and Table C-3 (for radiological parameters) and were obtained from the following sources:

- The Integrated Risk Information System (IRIS), a database available through the EPA National Center for Environmental Assessment (NCEA). IRIS, prepared and maintained by EPA, is an electronic database containing health risk and EPA regulatory information on specific chemicals (EPA 2001).
- The HEAST, provided by the EPA Office of Solid Waste and Emergency Response (EPA, 1997b) is a compilation of toxicity values published in various health effects documents issued by EPA.
- The U.S. EPA Region IX Preliminary Remediation Goal Table (November 2000) at www.epa.gov/docs/region09/waste/sfund/prg/index.html.

Where available, appropriate surrogate toxicity factors were used for detected chemicals without toxicity factors. 2-nitroaniline was selected as a surrogate for 3-nitroaniline and 4-nitroaniline; 4-nitrophenol was selected as a surrogate for 2-nitrophenol; acenaphthene was selected as a surrogate for acenaphthylene; PCB aroclor 1260 was selected as a surrogate for PCB aroclor 1268; pyrene was selected as a surrogate for benzo(g,h,i)perylene. Use of surrogate toxicity factors assumes the toxicity of structurally similar compounds is equivalent, which may result in an under- or overestimate of risks at the site.

Calcium, magnesium, potassium, and sodium are chemicals considered to be essential nutrients necessary for human nutrition.

RBCs were not calculated for the following nonradiological chemicals because appropriate surrogate toxicity values could not be identified:

- 3-methyl butanal, 4-bromophenyl-phenyl ether, 4-chloro-3-methylphenol, 4-chlorophenyl-phenyl ether, bis (2-chloroethoxy)methane, 1,1,3,4-tetrachlorobutane, 3,4-dimethyl decane, diacetone alcohol, dimethyl disulfide, eicosane, ethyl cyanide, famphur, 2,6,10,15-tetra heptadecane, isopropyl alcohol/2-propanol, mesityl oxide, 2,3,7-trimethyl octane, o-toluene sulfonamide, 2,6-bis(1,1-dimethyl) phenol, p-toluenesulfonamide, tributylphosphate, 4,6-dimethyl-undecane, chloride, lead, phosphorus, sulfate, sulfide, terbium, ytterbium, and zirconium.

RBCs were not calculated for the following radiological chemicals because slope factors were not available:

- Ac-225, Am-245, At-217, Ba-136m, Bi-212, Cm-241, Cm-242, Cm-243, Cs-134, Cs-135, Cs-136, Cs-137, Eu-154, Ln-114m, Np-235, Po-213, Rb-87, Rh-103m, Se-79, Tb-161, Th-234, and Tl-208.

Lack of appropriate toxicity factors for the above chemicals may result in an underestimation of risks at the site.

C.5 CALCULATION OF CUMULATIVE RBCS

Cumulative RBCs were calculated for each chemical following the development of individual RBCs. Each chemical with an RBC was categorized as either a carcinogen or noncarcinogen. For those chemicals that are considered as both a carcinogen and noncarcinogen, the lower of the two RBCs was selected. Cumulative RBCs for carcinogenic chemicals were derived by dividing the individual RBC for each carcinogen by the total number of carcinogenic chemicals identified. Similarly, cumulative RBCs for noncarcinogens were derived by dividing the individual RBC for each noncarcinogen by the total number of noncarcinogens identified. A summary of the groundwater RBCs developed for non-radiological and radiological constituents are presented at the end of this appendix in Tables C-4 through C-6.

C.6. REFERENCES

- EPA, 1991, *Risk Assessment Guidance for Superfund: Volume 1 – Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals)*, EPA/540/R-92/003, Environmental Protection Agency.
- EPA, 1992, *Dermal Exposure Assessment: Principles and Applications*, EPA/600/8-91/1011B, U.S. Environmental Protection Agency.
- EPA, 1997, *Health Effects Assessment Summary Tables (HEAST) FY 1997*, EPA-540-R-97-036, U.S. Environmental Protection Agency.
- EPA, 1998, *Risk Assessment Guidance for Superfund: Volume 1 – Human Health Evaluation Manual Supplemental Guidance Dermal Risk Assessment Interim Guidance*, U.S. Environmental Protection Agency.
- EPA, 2000, Region IX Preliminary Remediation Goal Chemical-Physical Data Table,
<http://www.epa.gov/docs/region09/waste/sfund/prg/index.html>, website visited November 2001.
- IRIA, 2000, Integrated Risk Information System, EPA National Center for Environmental Assessment (NCEA). <http://www.epa.gov/iris/>.

Table C-1. Summary of Exposure Assumptions.
 Fate and Transport Modeling Results and Summary Report
 ICDF

Parameter	Symbol	Residential	Source
Groundwater Risk-Based Concentration (mg/L or pCi/L)	RBC _{GW}	Calculated	--
Target Excess Lifetime Cancer Risk	TR	1.00E-04	--
Target Hazard Index	THI	1	--
Exposed individual	--	Adult & Child	--
Body weight - adult (kg)	BW _a	70	a
- child (kg)	BW _c	15	a
Groundwater ingestion rate - adult (mg/day)	IR _a	2	a
- child (mg/day)	IR _c	1	a
Age-adjusted water intake factor (L-year/kg-day)	IR _{adj}	1.09	--
Inhalation rate - adult (m ³ /day)	INH _a	20	b
- child (m ³ /day)	INH _c	10	b
Age-adjusted Inhalation Rate (m ³ -year/kg-day)	INH _{adj}	1.09	--
Volatilization factor (L/m ³)	VF	0.5	d
Exposed body parts - adult		Entire Body	--
- child		Entire Body	--
Exposed skin surface area - adult (cm ²)	SA _a	18000	c
- child (cm ²)	SA _c	6600	c
Age-adjusted surface area (cm ² -hr-yr/kg)	SA _{adj}	1992	--
Exposure time (hour/event) - adult	ET _a	0.25	c
- child (cm ²)	ET _c	0.17	c
Showering event frequency (event/day)		1	c
Dermal permeability constant (cm/hour)	K _p	Chemical-specific	see Table
Exposure frequency (days/year)	EF	350	a
Years exposed		30	a
Years over which exposure is averaged - adult	ATN _a	Noncancer - 24	a
- child	ATN _c	Noncancer - 6	a
	ATC	Cancer - 70	a

Notes:

- a. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive No. 928.6-03, March 25, 1991.
- b. USEPA Exposure Factors Handbook Volume I, General Factors. Office of Research and Development, EPA/600/P-95/002Fa, August 1997.
- c. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance Dermal Risk Assessment Interim Guidance. Office of Emergency and Remedial Response. Peer Consultation Workshop Draft. November 6, 1998.
- d. Andelman, J.B. 1990. Total Exposure to Volatile Organic Chemicals In Potable Water. N.M. Ram, R.F. Christman, K.P. Cantor (eds). Lewis Publishers.

Table C-2. Summary of Toxicity Factors for Non-Radiological Parameters.
Fate and Transport Modeling Results and Summary Report
ICDF

Chemical Name	Weight of Evidence Class	SFO (mg/kg-day) ⁻¹	RfDo (mg/kg-day)	Source	SFi (mg/kg-day) ⁻¹	Source	RfDI (mg/kg-day)	Source	Kp	Source
1,1,1-Trichloroethane	D	--	2.00E-02	e	--	--	2.86E-01	e	1.70E-02	p
1,1,2,2-Tetrachloroethane	C	2.00E-01	a	6.00E-02	e	2.03E-01	a	6.00E-02	d	9.00E-03
1,1,2-Trichloroethane	C	5.70E-02	a	4.00E-03	a	5.60E-02	a	4.00E-03	d	8.40E-03
1,1-Dichloroethane	C	--	1.00E-01	b	--	--	1.43E-01	b	8.90E-03	p
1,1-Dichloroethene	C	6.00E-01	a	9.00E-03	a	1.75E-01	a	9.00E-03	d	1.60E-02
1,2,4-Trichlorobenzene	D	--	1.00E-02	a	--	--	5.70E-02	b	1.00E-01	p
1,2-Dichlorobenzene	D	--	9.00E-02	a	--	--	5.71E-02	b	6.10E-02	p
1,2-Dichloroethane	B2	9.10E-02	a	3.00E-02	e	9.10E-02	a	1.40E-03	e	5.30E-03
1,2-Dichloroethene (total)	--	--	1.00E-02	b	--	--	1.00E-02	d	1.00E-02	p
1,3-Dichlorobenzene	D	--	9.00E-04	e	--	--	9.00E-04	d	8.70E-02	p
1,4-Dichlorobenzene	C	2.40E-02	b	3.00E-02	e	2.20E-02	e	2.29E-01	a	6.20E-02
1,4-Dioxane	B2	1.10E-02	a	--	1.10E-02	d	--	3.60E-04	p	5.90E-02
2,4,5-Trichlorophenol	--	--	1.00E-01	a	--	--	1.00E-01	d	5.00E-02	f
2,4,6-Trichlorophenol	B2	1.10E-02	a	--	1.09E-02	a	--	3.00E-03	d	2.30E-02
2,4-Dichlorophenol	--	--	3.00E-03	a	--	--	3.00E-03	d	2.00E-02	p
2,4-Dimethylphenol	--	--	2.00E-02	a	--	--	2.00E-02	d	1.50E-02	p
2,4-Dinitrophenol	--	--	2.00E-03	a	--	--	2.00E-03	d	1.80E-03	p
2,4-Dinitrotoluene	B2	--	2.00E-03	a	--	--	2.00E-03	d	3.80E-03	p
2,6-Dinitrotoluene	B2	--	1.00E-03	b	--	--	1.00E-03	d	2.50E-03	p
2-Butanone	D	--	6.00E-01	a	--	--	2.86E-01	a	1.10E-03	p
2-Chloronaphthalene	--	--	8.00E-02	a	--	--	8.00E-02	d	1.60E-01	f
2-Chlorophenol	--	--	5.00E-03	a	--	--	5.00E-03	d	1.10E-02	p
2-Hexanone	--	--	4.00E-02	c	--	--	1.40E-03	c	4.60E-03	f
2-Methylnaphthalene	--	--	2.00E-02	c	--	--	--	--	1.50E-01	f
2-Methylphenol	C	--	5.00E-02	a	--	--	5.00E-02	d	1.00E-02	p
2-Nitroaniline	--	--	5.71E-05	d	--	--	5.71E-05	b	5.20E-03	f
2-Nitrophenol	--	--	8.00E-03	g	--	--	8.00E-03	g	5.00E-03	p
3,3'-Dichlorobenzidine	B2	4.50E-01	a	--	4.50E-01	d	--	--	1.70E-02	p
3-Methyl Butanal*	--	--	--	--	--	--	--	--	--	--
3-Nitroaniline	--	--	5.71E-05	h	--	--	5.71E-05	h	5.20E-03	h
4,6-Dinitro-2-methylphenol	--	--	2.00E-03	i	--	--	2.00E-03	1	9.80E-03	f
4-Bromophenyl-phenylether*	--	--	--	--	--	--	--	--	2.40E-01	f
4-Chloro-3-methylphenol*	--	--	--	--	--	--	--	--	--	--
4-Chloroaniline	--	--	4.00E-03	a	--	--	4.00E-03	d	3.10E-02	f
4-Chlorophenyl-phenylether*	--	--	--	--	--	--	--	--	--	--
4-Methyl-2-Pentanone	C	--	8.00E-02	b	--	--	2.29E-02	b	3.30E-03	p
4-Methylphenol	C	--	5.00E-03	b	--	--	5.00E-03	d	1.00E-02	p
4-Nitroaniline	--	--	5.71E-05	i	--	--	5.71E-05	i	5.20E-03	f
4-Nitrophenol	D	--	8.00E-03	e	--	--	8.00E-03	d	6.10E-03	p
Acenaphthene	--	--	6.00E-02	a	--	--	6.00E-02	d	2.50E-01	f
Acenaphthylene	D	--	6.00E-02	j	--	--	6.00E-02	j	9.50E-02	f
Acetone	D	--	1.00E-01	a	--	--	1.00E-01	d	5.70E-04	f
Acetonitrile	--	--	6.00E-03	a	--	--	1.70E-02	a	6.10E-04	f
Acrolein	C	--	2.00E-02	b	--	--	5.71E-06	a	7.40E-04	p
Acrylonitrile	B1	5.40E-01	a	1.00E-03	b	--	2.38E-01	a	1.40E-03	p
Anthracene	D	--	3.00E-01	a	--	--	3.00E-01	d	2.20E-01	f

Table C-2. Summary of Toxicity Factors for Non-Radiological Parameters.
Fate and Transport Modeling Results and Summary Report
ICDF

Chemical Name	Weight of Evidence Class	SFO (mg/kg-day) ⁻¹	Source	RfDo (mg/kg-day)	Source	SFI (mg/kg-day) ⁻¹	Source	RfDi (day)	Source	Kp	Source
Aramite	B2	2.50E-02	a	5.00E-02	b	2.49E-02	a	5.00E-02	d	4.60E-02	f
Aroclor-1016	B2	7.00E-02	a	7.00E-05	a	7.00E-02	a	7.00E-05	d	7.90E-01	f
Aroclor-1254	B2	2.00E+00	a	2.00E-05	a	2.00E+00	a	2.00E-05	d	3.50E-01	f
Aroclor-1260	--	2.00E+00	a	--	--	2.00E+00	a	--	--	1.10E+00	f
Aroclor-1268	--	2.00E+00	o	--	--	2.00E+00	o	--	--	1.10E+00	o
Benzene	A	5.50E-02	a	3.00E-03	e	2.70E-02	a	1.71E-03	e	2.10E-02	p
Benzidine	A	2.30E+02	a	3.00E-03	a	2.30E+02	a	3.00E-03	d	1.30E-03	p
Benzo(a)anthracene	B2	7.30E-01	e	--	--	3.10E-01	e	--	--	8.10E-01	p
Benzo(a)pyrene	B2	7.30E+00	a	--	--	3.10E+00	e	--	--	1.20E+00	p
Benzo(b)fluoranthene	B2	7.30E-01	e	--	--	3.10E-01	e	--	--	1.20E+00	f
Benzo(g,h,i)perylene	D	--	--	3.00E-02	k	--	--	3.00E-02	k	1.80E+00	f
Benzo(k)fluoranthene	B2	7.30E-02	e	--	--	3.10E-02	e	--	--	6.00E-01	f
Benzoic acid	D	--	--	4.00E+00	a	--	--	4.00E+00	d	7.30E-03	f
bis(2-Chloroethoxy)methane*	--	--	--	--	--	--	--	--	--	1.40E-03	f
bis(2-Chloroethyl)ether	B2	1.10E+00	a	--	--	1.16E+00	a	--	--	2.10E-03	p
bis(2-Chloroisopropyl)ether	C	7.00E-02	b	4.00E-02	a	3.50E-02	b	4.00E-02	d	1.20E-02	f
bis(2-Ethylhexyl)phthalate	B2	1.40E-02	a	2.00E-02	a	1.40E-02	e	2.20E-02	d	3.30E-02	p
Butane,1,1,3,4-Tetrachloro-Butylbenzylphthalate	--	--	--	--	--	--	--	--	--	--	--
Carbazole	C	--	--	2.00E-01	a	--	--	2.00E-01	d	7.10E-02	f
Carbon Disulfide	B2	2.00E-02	b	--	--	2.00E-02	d	--	--	9.10E-02	f
Chlorobenzene	D	--	--	1.00E-01	a	--	--	2.00E-01	a	2.40E-02	p
Chloroethane	--	2.90E-03	e	2.00E-02	a	--	--	1.70E-02	e	4.10E-02	p
Chloromethane	C	1.30E-02	b	4.00E-01	e	2.90E-03	e	2.86E+00	a	8.00E-03	p
Chrysene	B2	7.30E-03	e	--	--	6.30E-03	b	8.60E-02	e	4.20E-03	p
Decane,3,4-Dimethyl*	--	--	--	--	--	3.10E-03	e	--	--	8.10E-03	p
Diacetone alcohol*	--	--	--	--	--	--	--	--	--	--	--
Dibenz(a,h)anthracene	B2	7.30E+00	e	--	--	3.10E+00	e	--	--	2.70E+00	p
Dibenzofuran	D	--	--	4.00E-03	e	--	--	4.00E-03	d	1.50E-01	f
Diethylphthalate	D	--	--	8.00E-01	a	--	--	8.00E-01	d	4.80E-03	p
Dimethyl Disulfide*	--	--	--	--	--	--	--	--	--	--	--
Dimethylphthalate	D	--	--	1.00E+01	a	--	--	1.00E+01	d	1.60E-03	p
Di-n-butylphthalate	D	--	--	1.00E-01	a	--	--	1.00E-01	d	3.30E-02	p
Di-n-octylphthalate	--	--	--	2.00E-02	b	--	--	2.00E-02	d	2.70E+01	f
Eicosane*	--	--	--	--	--	--	--	--	--	--	--
Ethyl benzene	D	--	--	1.00E-01	a	--	--	2.90E-01	a	7.40E-02	p
Famphur*	--	--	--	--	--	--	--	--	--	--	--
Fluoranthene	D	--	--	4.00E-02	a	--	--	4.00E-02	d	3.60E-01	p
Fluorene	D	--	--	4.00E-02	a	--	--	4.00E-02	d	2.50E-01	f
Heptadecane, 2,6,10,15-Tetra*	--	--	--	--	--	--	--	--	--	--	--
Hexachlorobenzene	B2	1.60E+00	a	8.00E-04	a	1.61E+00	a	8.00E-04	d	2.10E-01	p
Hexachlorobutadiene	C	7.80E-02	a	3.00E-04	e	7.80E-02	a	3.00E-04	d	1.20E-01	p
Hexachlorocyclopentadiene	D	--	--	7.00E-03	a	--	--	2.00E-05	b	2.90E-02	f
Hexachloroethane	C	1.40E-02	a	1.00E-03	a	1.40E-02	a	1.00E-03	d	4.20E-02	p
Indeno(1,2,3-cd)pyrene	B2	7.30E-01	e	--	--	3.10E-01	e	--	--	1.90E+00	p

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Chemical Name	Evidence Class	Weight of Evidence Class	SF _O (mg/kg-day) ¹	Source	RfDo (mg/kg-day)	SF _i (mg/kg-day) ¹	Source	(mg/kg-day) ¹	RfDi (day)	Source	K _p	Source
Isobutyl alcohol	C	9.50E-04	--	3.00E-01	a	9.50E-04	e	--	3.00E-01	d	2.60E-03	f
Isophorone			a	2.00E-01					2.00E-01	d	4.40E-03	p
Isopropyl Alcohol/2-propanol*			1.80E+01	e	--	1.80E+01	d	--	--	--	8.90E-04	f
Kepone			--	--	--	--					--	--
Mesityl oxide*			--	--	1.00E+00	b	--	--	1.00E+00	d	9.00E-04	f
Methyl Acetate	B2	7.50E-03	a	6.00E-02	a	1.65E-03	a	8.57E-01	b	4.50E-03	p	
Methylene Chloride	C	--	--	2.00E-02	a	--		8.57E-04	a	6.90E-02	p	
Naphthalene	B2	--	--	5.00E-04	a	--		5.71E-04	b	6.90E-03	f	
Nitrobenzene	B2	7.00E+00	a	--	7.00E+00	d	--	--	--	2.80E-03	f	
N-Nitroso-di-n-propylamine	B2	4.90E-03	a	--	4.90E-03	d	--	--	--	3.60E-02	p	
N-Nitrosodiphenylamine	B2	1.20E-01	a	3.00E-02	a	1.20E-01	d	3.00E-02	d	6.50E-01	p	
Octane,2,3,7-Trimethyl*	D	--	--	3.00E-01	a	--		3.00E-01	d	2.70E-01	p	
o-Toluenesulfonamide*	D	--	--	6.00E-01	a	--		6.00E-01	d	5.50E-03	p	
Pentachlorophenol	B2	--	--	--	--	--		--	--	--	--	
Phenanthrene	D	--	--	--	--	--		--	--	--	--	
Phenol	D	--	--	--	--	--		--	--	--	--	
Phenol,2,6-Bis(1,1-Dimethyl)*	--	--	--	--	--	--		--	--	--	--	
p-Toluenesulfonamide*	D	--	--	3.00E-02	a	--		3.00E-02	d	3.20E-01	f	
Pyrene	C	--	--	2.00E-01	a	--		2.90E-01	a	5.50E-02	p	
Styrene	C-B2	5.20E-02	e	1.00E-02	a	2.03E-03	e	1.14E-01	e	4.80E-02	p	
Tetrachloroethene	D	--	--	2.00E-01	a	--		1.10E-01	b	4.50E-02	p	
Toluene	--	--	--	--	--	--		--	--	--	--	
Tributyl phosphate*	--	--	--	--	--	--		--	--	--	--	
Trichloroethene	B2	1.10E-02	e	6.00E-03	a	6.00E-03	e	6.00E-03	d	1.60E-02	p	
Undecane,4,6-Dimethyl*	--	--	--	--	--	--		--	--	--	--	
Xylene (ortho)	D	--	--	2.00E+00	a	--		2.00E-01	a	8.00E-02	p	
Xylene (total)	--	--	--	2.00E+00	a	--		2.00E-01	a	8.00E-02	p	
Trinitrotoluene	--	3.00E-02	a	5.00E-04	a	3.00E-02	d	5.00E-04	d	1.60E-02	p	
RDX	--	1.10E-01	a	3.00E-03	a	1.10E-01	d	3.00E-03	d	1.90E-02	f	
Aluminum	--	--	--	1.00E+00	e	--		1.40E-03	e	1.00E-03	p	
Antimony	D	--	--	4.00E-04	a	--		--	--	1.00E-03	p	
Arsenic	A	1.50E+00	a	3.00E-04	a	1.51E+01	a	--	--	1.00E-03	p	
Barium	D	--	--	7.00E-02	a	--		1.43E-04	b	1.00E-03	p	
Beryllium	B1	--	--	2.00E-03	a	8.40E+00	a	5.71E-06	a	1.00E-03	p	
Boron	D	--	--	9.00E-02	a	--		5.71E-03	b	1.00E-03	p	
Cadmium	B1	--	--	5.00E-04	a	6.30E+00	a	--	--	1.00E-03	p	
Calcium*	--	--	--	--	--	--		--	--	1.00E-03	p	
Chloride*	A	--	--	--	--	--		4.20E+01	a	--	--	
Chromium	--	--	--	6.00E-02	e	--		--	--	1.00E-03	p	
Cobalt	D	--	--	3.71E-02	b	--		--	--	1.00E-03	p	
Copper	--	--	--	2.00E-02	a	--		8.57E-04	a	--	--	
Cyanide	--	--	--	2.00E-01	e	--		--	--	1.00E-03	p	
Dysprosium	--	--	--	6.00E-02	a	--		--	--	1.00E-03	p	
Fluoride	--	--	--	3.00E-01	e	--		--	--	1.00E-03	p	
Iron	--	--	--	--	--	--		--	--	--	--	
Lead*	--	--	--	--	--	--		--	--	--	--	

Table C-2. Summary of Toxicity Factors for Non-Radiological Parameters.
Fate and Transport Modeling Results and Summary Report
ICDF

Chemical Name	Weight of Evidence Class	SFO (mg/kg-day) ⁻¹	Source	RfDo (mg/kg-day)	Source	SFI (mg/kg-day) ⁻¹	Source	RfDi day)	Source	Kp	Source
Magnesium*	--	--	--	2.40E-02	a	--	--	1.40E-05	a	1.00E-03	p
Manganese	D	--	--	3.00E-04	a	--	--	--	--	1.00E-03	p
Mercury	D	--	--	5.00E-03	b	--	--	--	--	1.00E-03	p
Molybdenum	--	--	--	2.00E-02	a	--	--	--	--	1.00E-03	p
Nickel	D	--	--	1.00E-01	a	--	--	--	--	1.00E-03	p
Nitrate	--	--	--	--	--	--	--	--	--	--	--
Nitrate/Nitrite-N*	--	--	--	--	--	--	--	--	--	--	--
Nitrite	--	--	--	1.00E-01	a	--	--	--	--	--	--
Phosphorus*(q)	--	--	--	--	--	--	--	--	--	1.00E-03	p
Potassium*	--	--	--	--	--	--	--	--	--	1.00E-03	p
Selenium	D	--	--	5.00E-03	a	--	--	--	--	1.00E-03	p
Silver	D	--	--	5.00E-03	a	--	--	--	--	1.00E-03	p
Sodium*	--	--	--	--	--	--	--	--	--	1.00E-03	p
Strontium	--	--	--	6.00E-01	a	--	--	--	--	1.00E-03	p
Sulfate*	--	--	--	--	--	--	--	--	--	--	--
Sulfide*	--	--	--	--	--	--	--	--	--	--	--
Terbium*	--	--	--	--	--	--	--	--	--	1.00E-03	p
Thallium	D	--	--	6.60E-05	a	--	--	--	--	1.00E-03	p
Vanadium	--	--	--	7.00E-03	b	--	--	--	--	1.00E-03	p
Ytterbium*	--	--	--	--	--	--	--	--	--	1.00E-03	p
Zinc	D	--	--	3.00E-01	a	--	--	--	--	1.00E-03	p
Zirconium*	--	--	--	--	--	--	--	--	--	1.00E-03	p

Notes:

- a. US EPA. The Integrated Risk Information System (IRIS, 2000), a database available through the EPA National Center for Environmental Assessment (NCEA). <http://www.epa.gov/iris/>
- b. US EPA. Health Effects Assessment Summary Tables (HEAST) FY 1997 Update. EPA-540-R-97-036. July 1997.
- c. US EPA Region III RBC Tables. April 1999. <http://www.epa/reg3hwmd/risk/>
- d. Route to route extrapolation
- e. US EPA Region IX Preliminary Remediation Goals Table. November 22, 2000. http://www.epa.gov/region09/waste/sfund/prg/s1_01.htm
- f. Oak Ridge National Laboratory. October 2001. http://risk.lsd.ornl.gov/rap_hp.shtml
- g. Toxicity factors for 4-nitrophenol were used as surrogates for 2-nitrophenol
- h. Toxicity factors for 2-nitroaniline were used as surrogates for 3-nitroaniline
- i. Toxicity factors for 2-nitroaniline were used as surrogates for 4-nitroaniline
- j. Toxicity factors for acenaphthene were used as surrogates for acenaphthylene
- k. Toxicity factors for pyrene were used as surrogates for benzo(a,h,i)perylene
- l. Toxicity factors for 2,4-dinitrophenol were used as surrogates for 4,6-dinitro-2-methylphenol.
- m. US EPA Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance Dermal Risk Assessment. November 6, 1998.
- n. U. S. Environmental Protection Agency. 1996. Superfund Soil Screening Guidance: User's Guide, Second Edition. Office of Solid Waste and Emergency Response Publication 9355-4-35. July 1996.
- o. Toxicity factors for aroclor 1260 were used as surrogates for aroclor 1268.
- p. EPA. Dermal Exposure Assessment: Principles and Applications. Interim Report. EPA/600/8-91/011B. January 1992
- q. The reference dose for phosphorus is based on exposure to elemental phosphorus. Elemental phosphorus is unstable in the environment and rapidly oxidizes to the phosphate or orthophosphate oxyanion. Phosphorus present in the soil at t₁
- * No toxicity factors available for this chemical
- = not applicable or not available

Table C-3. Summary of Toxicity Factors for Radiological Parameters.

Fate and Transport Modeling Results and Summary Report

ICDF

Isotope ^a	Oral Slope Factor	
	(risk/pCi) ^{b,c}	Kp ^d
Ac225	--	1.00E-03
Ac227	5.59E-12	1.00E-03
Ac228	1.89E-10	1.00E-03
Ag106	6.92E-11	6.00E-04
Ag108	2.01E-10	6.00E-04
Ag108m	4.86E-10	6.00E-04
Ag109m	1.99E-12	6.00E-04
Ag110	7.25E-14	6.00E-04
Ag110m	1.20E-13	6.00E-04
Ag111	1.65E-13	6.00E-04
Am241	1.21E-13	1.00E-03
Am242	1.77E-12	1.00E-03
Am242m	5.92E-14	1.00E-03
Am243	4.81E-12	1.00E-03
Am245	--	1.00E-03
Am246	8.14E-12	1.00E-03
At217	--	1.00E-03
Ba136m	--	1.00E-03
Ba137m	9.88E-12	1.00E-03
Ba140	8.21E-12	1.00E-03
Be 10	1.99E-12	1.00E-03
Bi210	1.40E-13	1.00E-03
Bi211	1.73E-11	1.00E-03
Bi212	--	1.00E-03
Bi213	5.07E-14	1.00E-03
Bi214	9.62E-14	1.00E-03
Bk249	1.38E-12	1.00E-03
Bk250	2.59E-12	1.00E-03
C 14	1.04E-10	1.00E-03
Cd109	1.79E-12	1.00E-03
Cd113m	7.07E-11	1.00E-03
Cd115m	1.04E-10	1.00E-03
Ce141	1.03E-10	1.00E-03
Ce142	1.08E-10	1.00E-03
Ce144	2.52E-12	1.00E-03
Cf249	5.11E-14	1.00E-03
Cf250	2.22E-13	1.00E-03
Cf251	1.23E-13	1.00E-03
Cf252	6.59E-14	1.00E-03
Cm241	--	1.00E-03
Cm242	--	1.00E-03
Cm243	--	1.00E-03
Cm244	1.05E-13	1.00E-03
Cm245	3.20E-13	1.00E-03

Table C-3. Summary of Toxicity Factors for Radiological Parameters.
 Fate and Transport Modeling Results and Summary Report
 ICDF

Isotope ^a	Oral Slope Factor (risk/pCi) ^{b,c}	Kp ^d
Cm246	2.28E-12	1.00E-03
Cm247	1.02E-11	1.00E-03
Cm248	1.56E-12	1.00E-03
Cm250	6.70E-12	1.00E-03
Co-57	9.66E-12	4.00E-04
Co-58	2.50E-12	4.00E-04
Co-60	6.33E-13	4.00E-04
Cr-51	6.96E-13	1.00E-03
Cs132	3.37E-11	1.00E-03
Cs134	-	1.00E-03
Cs135	-	1.00E-03
Cs136	-	1.00E-03
Cs137	-	1.00E-03
Er169	7.36E-13	1.00E-03
Eu150	1.66E-12	1.00E-03
Eu152	1.50E-12	1.00E-03
Eu154	-	1.00E-03
Eu155	6.29E-12	1.00E-03
Eu156	7.44E-12	1.00E-03
Fe-59	2.78E-12	1.00E-03
Fr221	1.55E-13	1.00E-03
Fr223	5.44E-12	1.00E-03
Gd152	4.33E-14	1.00E-03
Gd153	8.51E-13	1.00E-03
H-3	1.52E-11	1.00E-03
Hf-181	2.00E-12	1.00E-03
Ho166m	9.25E-15	1.00E-03
I129	6.81E-12	1.00E-03
I131	3.19E-12	1.00E-03
In114	2.56E-12	1.00E-03
In114m	-	1.00E-03
In115	3.70E-13	1.00E-03
In115m	1.49E-11	1.00E-03
K-40	2.14E-13	2.00E-04
Kr81	9.29E-14	1.00E-03
Kr85	7.03E-12	1.00E-03
La138	8.66E-14	1.00E-03
La140	1.52E-13	1.00E-03
Mn-54	4.22E-13	1.00E-03
Nb93m	2.65E-13	1.00E-03
Nb94	1.92E-12	1.00E-03
Nb92	3.32E-12	1.00E-03
Nb95	7.73E-12	1.00E-03
Nb95m	5.66E-12	1.00E-03

Table C-3. Summary of Toxicity Factors for Radiological Parameters.

Fate and Transport Modeling Results and Summary Report

ICDF

Isotope ^a	Oral Slope Factor	
	(risk/pCi) ^{b,c}	Kp ^d
Nd144	8.92E-12	1.00E-03
Nd147	5.51E-11	1.00E-03
Np235	-	1.00E-03
Np236	7.10E-13	1.00E-03
Np237	5.11E-13	1.00E-03
Np238	1.92E-13	1.00E-03
Np239	3.43E-12	1.00E-03
Np240	2.01E-12	1.00E-03
Np240m	1.24E-10	1.00E-03
Pa231	1.11E-12	1.00E-03
Pa233	5.66E-13	1.00E-03
Pa234	1.50E-13	1.00E-03
Pa234m	2.46E-13	1.00E-03
Pb209	1.57E-13	1.00E-04
Pb210	1.45E-12	1.00E-04
Pb211	3.01E-13	1.00E-04
Pb212	4.70E-14	1.00E-04
Pb214	2.82E-13	1.00E-04
Pd107	1.71E-12	1.00E-03
Pm146	8.44E-14	1.00E-03
Pm147	1.48E-13	1.00E-03
Pm148	4.07E-14	1.00E-03
Pm148m	1.55E-12	1.00E-03
Po210	3.53E-13	1.00E-03
Po211	2.47E-12	1.00E-03
Po212	7.55E-12	1.00E-03
Po213	-	1.00E-03
Po214	1.72E-13	1.00E-03
Po215	3.50E-13	1.00E-03
Po216	5.00E-12	1.00E-03
Po218	2.28E-11	1.00E-03
Pr143	2.87E-11	1.00E-03
Pr144	8.66E-12	1.00E-03
Pr144m	1.70E-11	1.00E-03
Pu236	1.37E-12	1.00E-03
Pu237	1.22E-12	1.00E-03
Pu238	1.59E-11	1.00E-03
Pu239	3.81E-12	1.00E-03
Pu240	1.31E-13	1.00E-03
Pu241	3.47E-12	1.00E-03
Pu242	1.35E-12	1.00E-03
Pu243	4.63E-12	1.00E-03
Pu244	7.10E-12	1.00E-03
Pu246	3.52E-11	1.00E-03

Table C-3. Summary of Toxicity Factors for Radiological Parameters.
 Fate and Transport Modeling Results and Summary Report
 ICDF

Isotope ^a	Oral Slope Factor	
	(risk/pCi) ^{b,c}	Kp ^d
Ra222	3.53E-11	1.00E-03
Ra223	1.25E-13	1.00E-03
Ra224	2.11E-11	1.00E-03
Ra225	4.44E-11	1.00E-03
Ra226	1.27E-10	1.00E-03
Ra228	8.62E-11	1.00E-03
Rb86	1.32E-10	1.00E-03
Rb87	-	1.00E-03
Rh102	4.26E-12	1.00E-03
Rh103m	-	1.00E-03
Rh106	3.30E-12	1.00E-03
Rn218	1.93E-13	1.00E-03
Rn219	1.52E-13	1.00E-03
Rn220	3.28E-13	1.00E-03
Rn222	3.49E-11	1.00E-03
Ru103	4.85E-12	1.00E-03
Ru106	3.85E-11	1.00E-03
Sb124	9.47E-11	1.00E-03
Sb125	8.36E-11	1.00E-03
Sb126	1.04E-10	1.00E-03
Sb126m	1.02E-10	1.00E-03
Sc-46	9.95E-11	1.00E-03
Se 79	-	1.00E-03
Sm146	8.40E-14	1.00E-03
Sm147	4.63E-12	1.00E-03
Sm148	1.01E-11	1.00E-03
Sm149	1.04E-12	1.00E-03
Sm151	2.95E-12	1.00E-03
Sn117m	1.26E-13	1.00E-03
Sn119m	1.57E-11	1.00E-03
Sn121m	2.66E-15	1.00E-03
Sn123	2.43E-13	1.00E-03
Sn125	8.25E-14	1.00E-03
Sn126	7.44E-13	1.00E-03
Sr89	1.35E-13	1.00E-03
Sr90	1.85E-13	1.00E-03
Tb160	5.96E-14	1.00E-03
Tb161	-	1.00E-03
Tc 98	6.51E-14	1.00E-03
Tc 99	-	1.00E-03
Te123	1.85E-13	1.00E-03
Te123m	4.74E-14	1.00E-03
Te125m	1.86E-13	1.00E-03
Te127	1.46E-12	1.00E-03

Table C-3. Summary of Toxicity Factors for Radiological Parameters.
Fate and Transport Modeling Results and Summary Report
ICDF

Isotope ^a	Oral Slope Factor	
	(risk/pCi) ^{b,c}	Kp ^d
Te127m	4.22E-11	1.00E-03
Te129	4.14E-14	1.00E-03
Te129m	4.74E-12	1.00E-03
Th226	4.51E-14	1.00E-03
Th227	8.66E-12	1.00E-03
Th228	3.04E-11	1.00E-03
Th229	3.04E-11	1.00E-03
Th230	1.58E-13	1.00E-03
Th231	1.37E-13	1.00E-03
Th232	4.63E-13	1.00E-03
Th234	-	1.00E-03
Tl207	6.40E-13	1.00E-03
Tl208	-	1.00E-03
Tl209	1.94E-12	1.00E-03
Tm170	5.25E-13	1.00E-03
Tm171	2.26E-13	1.00E-03
U230	5.29E-13	1.00E-03
U232	4.14E-13	1.00E-03
U233	1.11E-11	1.00E-03
U234	3.15E-13	1.00E-03
U235	8.95E-14	1.00E-03
U236	2.53E-12	1.00E-03
U237	2.02E-12	1.00E-03
U238	5.99E-12	1.00E-03
U240	5.96E-14	1.00E-03
Xe127	1.02E-12	1.00E-03
Xe129m	3.49E-11	1.00E-03
Xe131m	5.51E-11	1.00E-03
Xe133	2.73E-11	1.00E-03
Y90	2.73E-12	1.00E-03
Y91	4.55E-12	1.00E-03

Table C-3. Summary of Toxicity Factors for Radiological Parameters.

Fate and Transport Modeling Results and Summary Report

ICDF

Isotope ^a	Oral Slope Factor	
	(risk/pCi) ^{b,c}	Kp ^d
Zn65	2.02E-12	1.00E-03
Zr93	4.29E-12	1.00E-03
Zr95	5.14E-13	1.00E-03

Notes

a. For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included. Refer to Exhibit 1 in the User's Guide section on radionuclide carcinogenicity for guidance on determining slope factors for partial or complete radioactive

b. The curie (Ci), the customary unit of activity is equal to 3.7×10^{10} nuclear transformations per second. 1 picocurie (pCi) = 10^{-12} Ci. The International System (SI) unit of activity is the becquerel (1 Bq = 1 nuclear transformation per second).

c. EPA. Radiation Protection Programs, Radiation Slope Factors at the web site <http://www.epa.gov/radiation/heast/>
d. EPA guidance recommends using a default Kp of 1×10^{-3} cm/hr for inorganic compounds unless otherwise noted. Source: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance, EPA, November 6, 1998.

For radioisotopes of iodine, the values listed for food ingestion represent ingestion of milk; corresponding values for ingestion of nondairy foods would be lower by a factor of approximately 2.

For radioisotopes of mercury, Federal Guidance Report No. 13 provides values for inorganic compounds, organic compounds, and methyl mercury for ingestion of each isotope. The ingestion values reported in Table 4 for each isotope represent the maximum of these three forms.

For radioisotopes of polonium, Federal Guidance Report No. 13 provides values for ingestion of organic ($f_1=0.5$) and inorganic ($f_1=0.1$) compounds. For purposes of this tabulation, polonium is assumed to be ingested in organic form in foods and in inorganic form in water and soil.

For radioisotopes of sulfur, Federal Guidance Report No. 13 provides values for ingestion of both organic and inorganic compounds. For the purpose of this tabulation, sulfur is assumed to be ingested in organic form in foods and in inorganic form for ingestion of water and soil.

Table C-4. Summary of Groundwater Carcinogenic RBCs for Non-Radiological Parameters.
Residential Exposure Scenario
ICDF

Chemical	Individual RBC (mg/L)
1,1,2,2-Tetrachloroethane	5.52E-03
1,1,2-Trichloroethane	1.99E-02
1,1-Dichloroethene	4.50E-03
1,4-Dichlorobenzene	4.92E-02
1,4-Dioxane	6.11E-01
2,4,6-Trichlorophenol	5.60E-01
3,3'-Dichlorobenzidine	1.45E-02
Aramite	2.48E-01
Aroclor-1260	1.11E-03
Aroclor-1268	1.11E-03
Benzidine	2.92E-05
Benzo(a)anthracene	3.71E-03
Benzo(a)pyrene	2.88E-04
Benzo(b)fluoranthene	2.88E-03
Benzo(k)fluoranthene	4.38E-02
bis(2-Chloroethyl)ether	9.77E-04
bis(2-Chloroisopropyl)ether	2.73E-02
bis(2-Ethylhexyl)phthalate	4.53E-01
Carbazole	2.88E-01
Chloroethane	3.85E-01
Chloromethane	1.51E-01
Chrysene	9.08E-01
Dibenz(a,h)anthracene	1.55E-04
Hexachlorobenzene	3.03E-03
Indeno(1,2,3-cd)pyrene	2.05E-03
Methylene Chloride	4.26E-01
N-Nitroso-di-n-propylamine	9.56E-04
N-Nitrosodiphenylamine	1.29E+00
Pentachlorophenol	2.56E-02
Tetrachloroethene	1.01E-01
RDX	5.91E-02
Arsenic	4.47E-03

Table C-5. Summary of Groundwater Noncarcinogenic RBCs for Non-Radiological Parameters.
 Residential Exposure Scenario
 ICDF

Chemical	Individual RBC (mg/L)
1,1,1-Trichloroethane	4.17E-01
1,1-Dichloroethane	6.38E-01
1,2,4-Trichlorobenzene	1.40E-01
1,2-Dichlorobenzene	2.89E-01
1,2-Dichloroethane	7.99E-03
1,2-Dichloroethene (total)	4.79E-02
1,3-Dichlorobenzene	4.21E-03
2,4,5-Trichlorophenol	2.60E+00
2,4-Dichlorophenol	8.29E-02
2,4-Dimethylphenol	5.61E-01
2,4-Dinitrophenol	5.74E-02
2,4-Dinitrotoluene	5.72E-02
2,6-Dinitrotoluene	2.87E-02
2-Butanone	1.50E+00
2-Chloronaphthalene	3.66E-01
2-Chlorophenol	2.39E-02
2-Hexanone	1.14E+00
2-Methylnaphthalene	4.52E-01
2-Methylphenol	1.41E+00
2-Nitroaniline	2.74E-04
2-Nitrophenol	2.28E-01
3-Nitroaniline	2.74E-04
4,6-Dinitro-2-methylphenol	5.66E-02
4-Chloroaniline	1.09E-01
4-Methyl-2-Pentanone	1.25E-01
4-Methylphenol	1.41E-01
4-Nitroaniline	2.74E-04
4-Nitrophenol	2.28E-01
Acenaphthene	2.68E-01
Acenaphthylene	2.80E-01
Acetone	4.80E-01
Acetonitrile	6.25E-02
Acrolein	3.29E-05
Acrylonitrile	2.95E-03
Anthracene	1.35E+00
Aroclor-1016	8.24E-04
Aroclor-1254	3.51E-04
Benzene	8.81E-03
Benzo(g,h,i)perylene	2.01E-01
Benzoic acid	1.14E+02
Butylbenzylphthalate	5.10E+00
Carbon Disulfide	8.13E-01
Chlorobenzene	8.28E-02
Dibenzofuran	1.84E-02
Diethylphthalate	2.29E+01

Table C-5. Summary of Groundwater Noncarcinogenic RBCs for Non-Radiological Parameters.
Residential Exposure Scenario
ICDF

Chemical	Individual RBC (mg/L)
Dimethylphthalate	2.87E+02
Di-n-butylphthalate	4.75E-01
Di-n-octylphthalate	1.04E-02
Ethylbenzene	1.01E+00
Fluoranthene	6.94E-01
Fluorene	7.90E-01
Hexachlorobutadiene	7.09E-03
Hexachlorocyclopentadiene	1.92E-01
Hexachloroethane	2.68E-02
Isobutyl alcohol	8.60E+00
Isophorone	5.72E+00
Methyl Acetate	4.80E+00
Naphthalene	4.89E-03
Nitrobenzene	2.67E-03
Phenanthrene	5.78E+00
Phenol	1.71E+01
Pyrene	5.45E-01
Styrene	1.27E+00
Toluene	5.66E-01
Trichloroethene	2.87E-02
Xylene (ortho)	1.13E+00
Xylene (total)	1.13E+00
Trinitrotoluene	1.40E-02
Aluminum	2.88E+01
Antimony	1.14E-02
Barium	1.97E+00
Beryllium	4.57E-02
Boron	2.59E+00
Cadmium	1.39E-02
Cobalt	1.73E+00
Copper	1.07E+00
Iron	8.63E+00
Manganese	6.71E-01
Mercury	8.42E-03
Molybdenum	1.44E-01
Nickel	5.51E-01
Nitrate	4.60E+01
Nitrite	2.88E+00
Selenium	1.44E-01
Silver	1.38E-01
Strontium	1.73E+01
Thallium	1.90E-03
Vanadium	1.88E-01
Zinc	8.63E+00

Table C-6. Summary of Groundwater Carcinogenic RBCs for Radiological Parameters.
 Residential Exposure Scenario
 ICDF

Chemical	Individual RBC (mg/L)
Ac225	2.79E+01
Ac227	2.63E+01
Ac228	2.65E+03
Ag106	8.93E+04
Ag108	--
Ag108m	6.49E+02
Ag109m	--
Ag110	--
Ag110m	5.35E+02
Ag111	6.44E+02
Am241	5.08E+01
Am242	2.95E+03
Am242m	7.47E+01
Am243	5.13E+01
Am245	2.38E+04
Am246	4.29E+04
At217	--
Ba136m	--
Ba137m	--
Ba140	3.54E+02
Be 10	7.51E+02
Bi210	5.92E+02
Bi211	--
Bi212	7.44E+03
Bi213	1.03E+04
Bi214	2.75E+04
Bk249	4.76E+03
Bk250	9.33E+03
C 14	3.41E+03
Cd109	1.06E+03
Cd113m	1.84E+02
Cd115m	3.11E+02
Ce141	1.14E+03
Ce142	--
Ce144	1.50E+02
Cf249	4.16E+01
Cf250	6.13E+01
Cf251	4.00E+01
Cf252	--
Cm241	1.09E+03
Cm242	1.37E+02
Cm243	5.58E+01
Cm244	6.32E+01
Cm245	5.08E+01
Cm246	5.18E+01

Table C-6. Summary of Groundwater Carcinogenic RBCs for Radiological Parameters.
 Residential Exposure Scenario
 ICDF

Chemical	Individual RBC (mg/L)
Cm247	5.31E+01
Cm248	--
Cm250	--
Co-57	5.08E+03
Co-58	1.79E+03
Co-60	3.37E+02
Cr-51	2.85E+04
Cs132	3.62E+03
Cs134	1.25E+02
Cs135	1.11E+03
Cs136	6.10E+02
Cs137	1.74E+02
Er169	2.09E+03
Eu150	2.22E+03
Eu152	8.70E+02
Eu154	5.13E+02
Eu155	2.78E+03
Eu156	4.16E+02
Fe-59	6.70E+02
Fr221	--
Fr223	7.24E+02
Gd152	1.78E+02
Gd153	3.47E+03
H-3	1.04E+05
Hf-181	8.30E+02
Ho166m	5.73E+02
I129	3.57E+01
I131	1.16E+02
In114	--
In114m	2.13E+02
In115	1.56E+02
In115m	1.20E+04
K-40	2.14E+02
Kr81	--
Kr85	--
La138	1.50E+03
La140	4.80E+02
Mn-54	2.32E+03
Nb93m	6.58E+03
Nb94	6.80E+02
Nb92	--
Nb95	2.16E+03
Nb95m	1.44E+03
Nd144	--
Nd147	7.59E+02

Table C-6. Summary of Groundwater Carcinogenic RBCs for Radiological Parameters.
Residential Exposure Scenario
ICDF

Chemical	Individual RBC (mg/L)
Np235	1.53E+04
Np236	5.03E+02
Np237	8.54E+01
Np238	9.78E+02
Np239	1.03E+03
Np240	2.37E+04
Np240m	--
Pa231	3.05E+01
Pa233	9.51E+02
Pa234	2.06E+03
Pa234m	--
Pb209	2.19E+04
Pb210	6.00E+00
Pb211	1.29E+04
Pb212	2.12E+02
Pb214	1.54E+04
Pd107	2.11E+04
Pm146	1.26E+03
Pm147	3.12E+03
Pm148	3.07E+02
Pm148m	6.61E+02
Po210	1.40E+01
Po211	--
Po212	--
Po213	--
Po214	--
Po215	--
Po216	--
Po218	--
Pr143	6.67E+02
Pr144	6.52E+04
Pr144m	--
Pu236	7.07E+01
Pu237	9.15E+03
Pu238	4.03E+01
Pu239	3.91E+01
Pu240	3.91E+01
Pu241	3.00E+03
Pu242	4.12E+01
Pu243	1.11E+04
Pu244	3.85E+01
Pu246	3.05E+02
Ra222	--
Ra223	2.22E+01
Ra224	3.16E+01

Table C-6. Summary of Groundwater Carcinogenic RBCs for Radiological Parameters.
 Residential Exposure Scenario
 ICDF

Chemical	Individual RBC (mg/L)
Ra225	4.63E+01
Ra226	1.37E+01
Ra228	5.08E+00
Rb86	5.34E+02
Rb87	1.01E+03
Rh102	6.86E+02
Rh103m	5.62E+05
Rh106	--
Rn218	--
Rn219	--
Rn220	--
Rn222	--
Ru103	1.37E+03
Ru106	1.25E+02
Sb124	4.09E+02
Sb125	1.21E+03
Sb126	4.76E+02
Sb126m	7.93E+04
Sc-46	8.49E+02
Se 79	7.24E+02
Sm146	1.28E+02
Sm147	1.41E+02
Sm148	--
Sm149	--
Sm151	9.51E+03
Sn117m	1.21E+03
Sn119m	2.39E+03
Sn121m	2.26E+03
Sn123	3.77E+02
Sn125	2.63E+02
Sn126	2.06E+02
Sr89	4.12E+02
Sr90	9.45E+01
Tb160	6.07E+02
Tb161	1.11E+03
Tc 98	7.44E+02
Tc 99	1.92E+03
Te123	1.28E+03
Te123m	1.28E+03
Te125m	1.59E+03
Te127	5.28E+03
Te127m	6.13E+02
Te129	3.09E+04
Te129m	3.45E+02
Th226	7.93E+03

Table C-6. Summary of Groundwater Carcinogenic RBCs for Radiological Parameters.
 Residential Exposure Scenario
 ICDF

Chemical	Individual RBC (mg/L)
Th227	1.11E+02
Th228	4.93E+01
Th229	2.36E+01
Th230	5.80E+01
Th231	2.39E+03
Th232	5.23E+01
Th234	2.29E+02
Tl207	--
Tl208	--
Tl209	--
Tm170	5.92E+02
Tm171	7.55E+03
U230	2.53E+01
U232	1.81E+01
U233	7.35E+01
U234	7.47E+01
U235	7.59E+01
U236	7.88E+01
U237	1.08E+03
U238	8.25E+01
U240	7.51E+02
Xe127	--
Xe129m	--
Xe131m	--
Xe133	--
Y90	2.92E+02
Y91	3.30E+02
Zn65	4.51E+02
Zr93	4.76E+03
Zr95	1.15E+03

Appendix D

Effects of Recharge Rate Change on Remedial Action Objectives

Appendix D

Effects of Recharge Rate Change on Remedial Action Objectives

D.1 CUMULATIVE HAZARD INDEX REDUCTION BY DESIGN COVER, DESIGN LIFE OF 1,000 YEARS.

The following provide a comparison of the various components of the remedial action objects based on modifications in the recharge rate from 0.01 m/year, the natural recharge rate, and 0.0001 m/year, the design recharge rate. The graphs are based on the design inventory concentrations of the waste soil as they are modeled to groundwater.

- Cumulative hazard index (HI) for the two recharge rates is provided in Figures D-1 and D-2
- Cumulative Excess Lifetime Cancer Risk is provided in Figures D-3 and D-4
- Reduction in total alpha emitters is provided in Figures D-5 and D-6

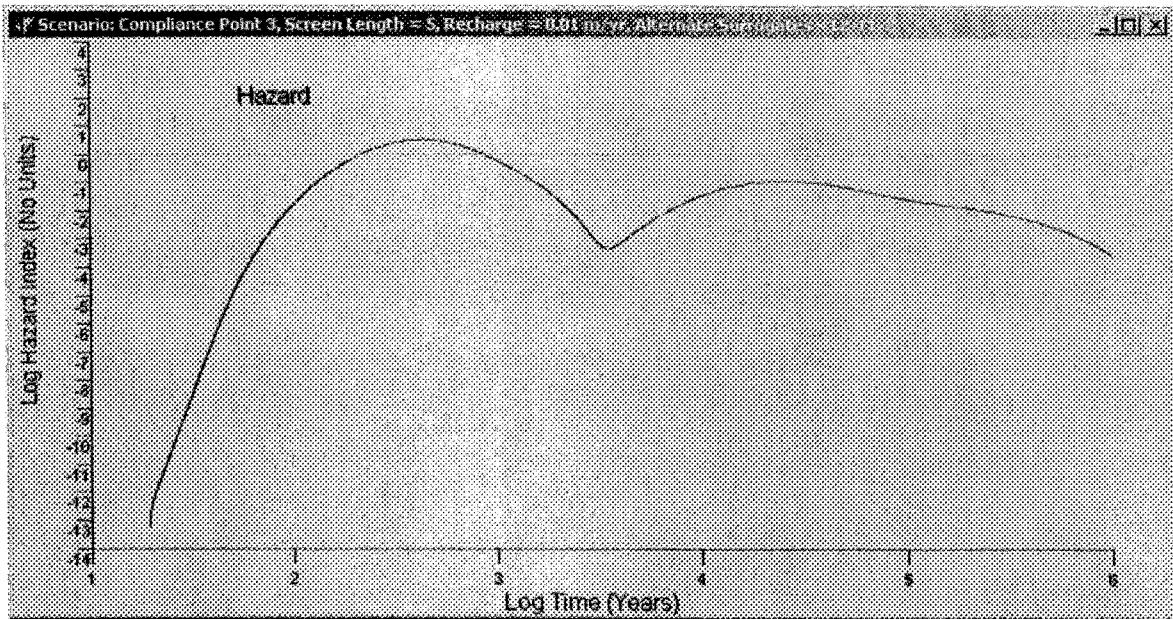


Figure D-1. Cumulative HI at background recharge of 0.01 m/yr.

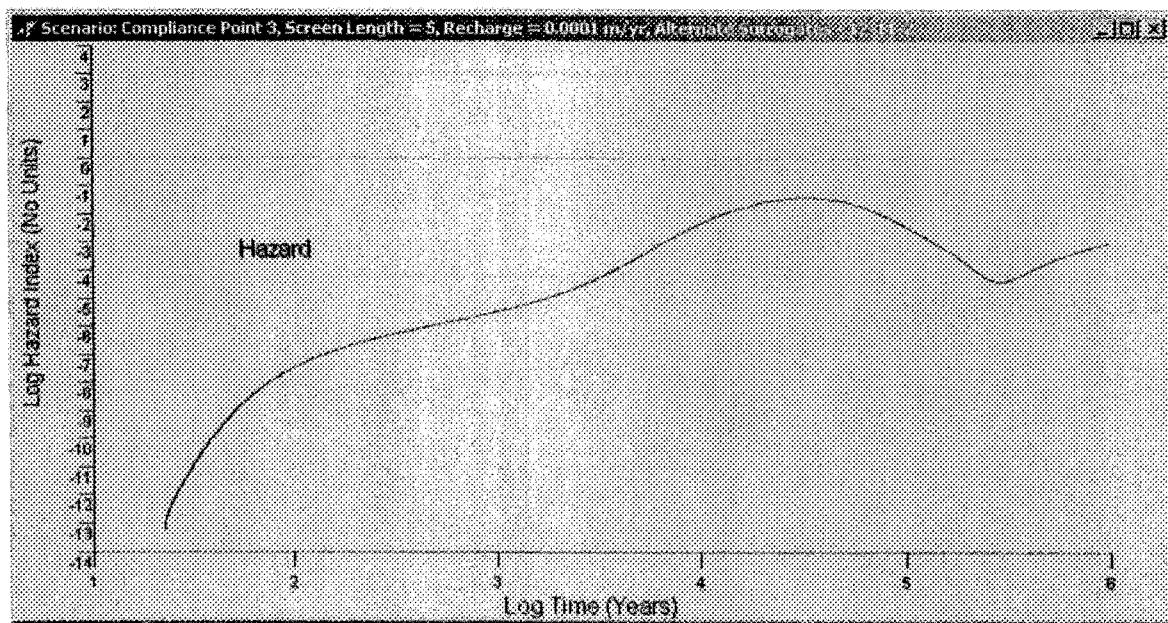


Figure D-2. Cumulative HI at cover recharge rate of 0.0001 m/yr.

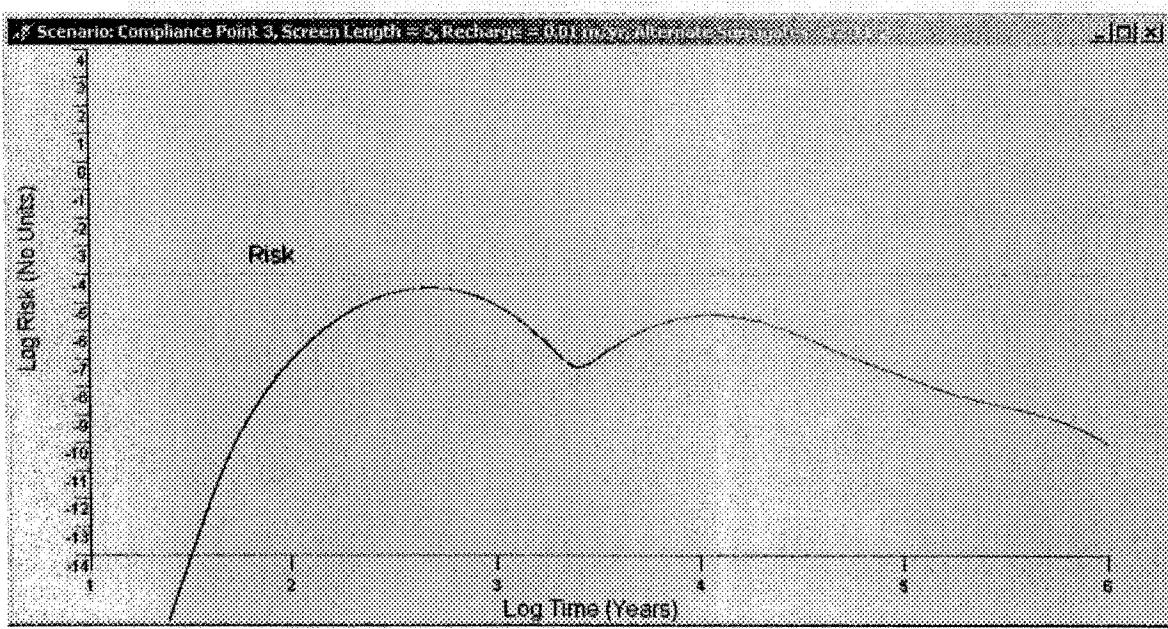


Figure D-3. Cumulative excess lifetime carcinogenic risk at background recharge of 0.01 m/yr.

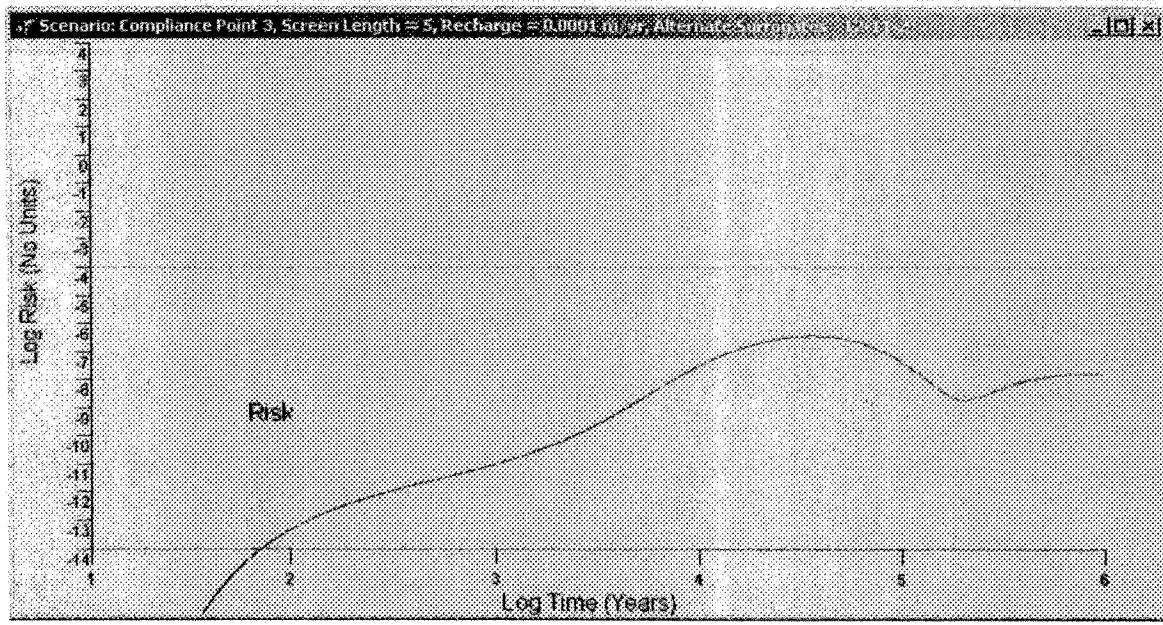


Figure D-4. Cumulative excess carcinogenic risk at design cover recharge rate of 0.0001 m/yr.

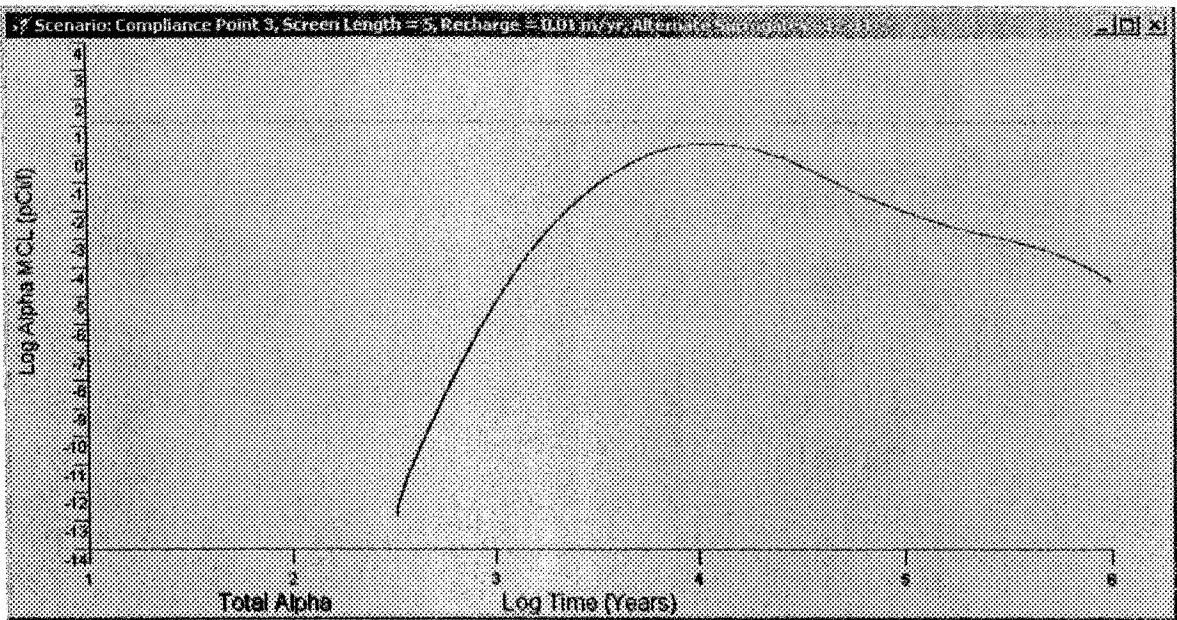


Figure D-5. Total alpha emitter concentration at background recharge rate of 0.01 m/yr.

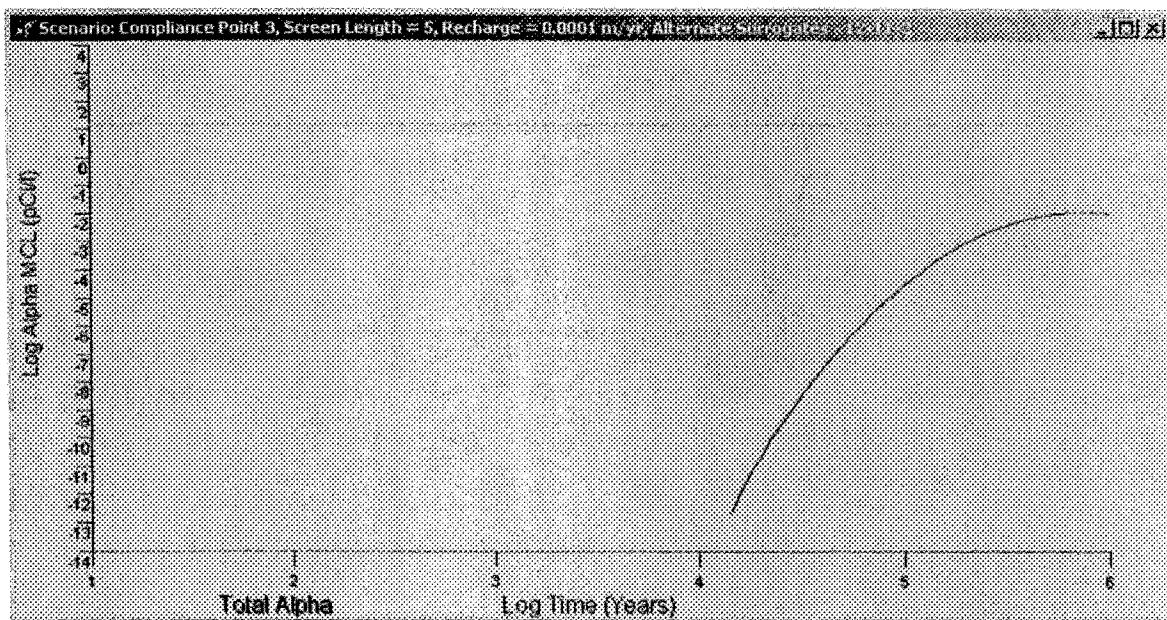


Figure D-6. Total alpha emitter concentration at design cover recharge rate of 0.0001 m/yr.

Appendix E

STOMP Input Files

E.1. STEADY STATE INPUT

-Simulation Title Card

1,
B Pond Lengthwise Cross Section,
WJ McMahon,
CH2M Hill Hanford,
August 17 2001,
10:00 AM PDT,

3,
This input file is the contaminant transport run for the INEEL ICDF simulation

This construction uses the geology developed by Pete Martian
The input parameters are based on PM reports

-Solution Control Card

normal,
Water,
1,
0,day,500000,yr,6,s,50000,yr,1.25,8,1.e-6,
3000,
0,

-Grid Card

cartesian,
60,1,98,
X Dimensions::160 m ICDF cell Total X Dimension 320 m
0.,m,6@15.,m,5@10.,m,2@5.,m,2@5.,m,
#20 m to screening model compliance point,
2@5.,m,1@4.,m,1@3.,m,1@2.,m,1@1.,m,
#190 feet (or 58 m) to edge of landfill cap (less 20 m above)
2@2.,m,1@3.,m,1@4.,m,2@6.,m,1@4.,m,2@3.,m,2@2.,m,1@1.,m,
#190 feet (or 58 m) plus 20 m (less 58 m above)
2@2.,m,1@3.,m,1@4.,m,2@3.,m,1@2.,m,1@1.,m,
#190 feet (or 58 m) plus 100 m (less 78 m above)
2@2.,m,1@3.,m,2@4.,m,2@5.,m,5@8.,m,1@5.,m,1@4.,m,1@3.,m,1@2.,m,1@1.,m,
#One grid block to move last observation point off of boundary
2@1.,m,
Y Dimensions (Y dimension not used)
0.,m,1.,m,
Z Dimensions
#Basalt Aquifer (Total = 76 m, Begin and End Lower 61 m) 9 Rows (Ignore 0)
0.,m,2@12.,m,2@8.,m,2@6.,m,1@4.,m,1@3.,m,1@2.,m,
#Basalt Aquifer Begin First 9 m of Upper 15 m 6 Rows
6@1.5,m,
#Basalt Aquifer Begin and End Upper 6 m
(7 m or 22 ft-note 6 m saturated and 1 m above water table) 6 Rows
1@1.,m,1@1.,m,1@1.,m,1@1.,m,1@1.,m,1@2.,m,
#Basalt (16.98 m or 57 ft-note that 1 m added to aquifer layer, 17.98 m = 59 ft)
7 Rows
1@2.,m,1@2.32,m,1@2.75,m,1@3.25,m,1@3.,m,1@2.15,m,1@1.51,m,
#Sedimentary Interbed (7.01 m or 23 ft) 4 Rows
1@1.51,m,1@2.,m,1@2.,m,1@1.5,m,
#Basalt (39.93 m or 131 ft) 13 Rows
1@1.5,m,1@2.,m,1@3.,m,1@4.,m,1@4.,m,1@4.5,m,1@4.5,m,1@4.,m,1@3.,m,1@2.4,m,

1@1.81,m,1@1.22,m,
 #Sedimentary Interbed (4.88 m or 16 ft) 4 Rows
 1@1.22,m,1@1.22,m,1@1.22,m,1@1.22,m,
 #Basalt (23.47 m or 77 ft) 9 Rows
 1@1.22,m,1@2,m,1@3,m,1@3.5,m,1@3.75,m,1@3.5,m,1@3,m,1@2,m,1@1.5,m,
 #Sedimentary Interbed (11.89 m or 39 ft) 6 Rows
 1@1.5,m,1@1.94,m,1@2.45,m,1@2.45,m,1@2.15,m,1@1.4,m,
 #Basalt (26.52 m or 87 ft) 13 Rows
 1@1.4,m,1@2,m,1@3,m,1@5,m,1@5,m,1@3,m,1@1.57,m,1@1.2,m,1@1,m,1@0.6,m,
 1@0.45,m,1@0.3,m,
 #Alluvium changed from 9 to 5 feet (1.52 m or 5 ft) 4 Rows
 1@0.30,m,1@0.46,m,1@0.46,m,1@0.30,m,
 #Clay Liner (0.91 m or 3 ft) 3 Rows
 1@0.30,m,1@0.31,m,1@0.30,m,
 #Operations Layer (0.91 m or 3 ft) 3 Rows
 1@0.30,m,1@0.31,m,1@0.30,m,
 #Waste (10.40 m or 34 ft adjusted to 12.56 m to account for cube vs
 trapezoid)
 # 11 Rows
 1@0.5,m,1@0.5,m,1@1,m,1@1,m,1@1.64,m,1@1.64,m,1@1.64,m,1@1.64,m,1@1,m,1
 @1,m,

~Rock/Soil Zonation Card

14,
 #Lower 61 m of Basalt Aquifer
 Basalt Aquifer,1,60,1,1,1,9,
 #Begin First 9 m of Upper 15 m of Basalt Aquifer
 Basalt Aquifer,1,60,1,1,10,15,
 #Upper 6 m of Basalt Aquifer
 Basalt Aquifer,1,60,1,1,16,21,
 #Lowest Vadose Basalt Layer
 Basalt,1,60,1,1,22,28,
 Interbed,1,60,1,1,29,32,
 Basalt,1,60,1,1,33,45,
 Interbed,1,60,1,1,46,49,
 Basalt,1,60,1,1,50,58,
 Interbed,1,60,1,1,59,64,
 Basalt,1,60,1,1,65,77,
 Alluvium,1,60,1,1,78,81,
 Clay,1,60,1,1,82,84,
 Operation Gravelly Sand,1,60,1,1,85,87,
 Waste Gravelly Sand,1,60,1,1,88,98,

~Inactive Nodes Card

#Integer,
 1,
 16,60,1,1,22,98,

~Mechanical Properties Card

#Particle density = 2650 kg/m^3 except for clay and old alluvium
 #Subgrade, attenuation barrier, and drain rock used in earlier models but
 #not used here
 #Basalt and interbed properties from P. Martian Screening Model
 Basalt Aquifer,,,0.06,0.06,,,Millington and Quirk,
 Interbed,,,0.487,0.487,,,Millington and Quirk,
 Basalt,,,0.05,0.05,,,Millington and Quirk,
 #

```

#Old Alluvium characteristics from Geotech report measurements
# sat. moisture content (0.422, 0.426); dry bulk density (1.60, 1.64 g/cm^3)
# particle density = 1.62 g/cm^3/(1-0.424) = 2.8125 g/cm^3
Alluvium,2812.5,kg/m^3,0.424,0.424,,,Millington and Quirk,
#Attenuation Barrier,,,0.400,0.400,,,Millington and Quirk,
#Clay characteristics per discussion with J. Dehner
Clay,2600,kg/m^3,0.390,0.390,,,Millington and Quirk,
#Drain Rock,,,0.400,0.400,,,Millington and Quirk,
Operation Gravelly Sand,,,0.275,0.275,,,Millington and Quirk,
#Operation Gravelly Sand dry bulk density = 120 lb/ft^3 (per J. Dehner)
#120 lb/ft^3*0.4536 kg/lb*1 ft^3/(0.3048 m/ft)^3 = 1922.25 kg/m^3
#Porosity Operation Gravelly Sand = 1-(1922.25/2650)= 0.275
Waste Gravelly Sand,,,0.266,0.266,,,Millington and Quirk,
#Waste Gravelly Sand dry bulk density = 121.5 lb/ft^3 (per J. Dehner)
#121.5 lb/ft^3*0.4536 kg/lb*1 ft^3/(0.3048 m)^3 = 1946.28 kg/m^3
#Porosity Waste Gravelly Sand = 1-(1946.28/2650)= 0.266

```

~Hydraulic Properties Card

```

#Properties from P. Martian Screening Model except old alluvium
Basalt Aquifer,9.00e+01,darcy,,,3.00e-01,darcy,
Interbed,6.7e-5,hc:cm/s,,,6.7e-5,hc:cm/s,
Basalt,9.00e+01,darcy,,,3.00e-01,darcy,
#Old Alluvium characteristics from Geotech report measurements
# sat. hydraulic conductivity (1.2e-07 cm/s, 6.2e-08 cm/s, 7.1e-08 cm/s)
Alluvium,1.2e-07,hc:cm/s,,,1.2e-07,hc:cm/s,
#Subgrade,1e-04,hc:cm/s,,,1e-04,hc:cm/s,
#Attenuation Barrier,1e-07,hc:cm/s,,,1e-07,hc:cm/s,
Clay,1e-07,hc:cm/s,,,1e-07,hc:cm/s,
#Drain Rock,3.0e-01,hc:cm/s,,,3.0e-01,hc:cm/s,
Operation Gravelly Sand,1e-04,hc:cm/s,,,1e-04,hc:cm/s,
Waste Gravelly Sand,1e-03,hc:cm/s,,,1e-03,hc:cm/s,

```

~Saturation Function Card

```

#Parameters from P. Martian Screening Model except old alluvium
#alpha, n, theta R, m
#m only specified for basalts, otherwise default m = 1 - 1/n
Basalt Aquifer,Nonhysteretic van Genuchten,4.0,1/m,4.5,0.0002,0.7777778,
Interbed,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.142,,
Basalt,Nonhysteretic van Genuchten,4.0,1/m,4.5,0.0002,0.7777778,
#Old Alluvium characteristics from RETC fitting of Geotech report
measurements
Alluvium,Nonhysteretic van Genuchten,0.595,1/m,1.108,0.142,,,
#Subgrade,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.142,,,
#Attenuation Barrier,Nonhysteretic van Genuchten,0.800,1/m,1.090,0.07,,,
Clay,Nonhysteretic van Genuchten,0.800,1/m,1.09,0.07,,,
#Drain Rock,Nonhysteretic van Genuchten,493,1/m,2.190,0.005,,,
Operation Gravelly Sand,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.083,,,
Waste Gravelly Sand,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.072,,,
#

```

~Aqueous Relative Permeability Card

```

#m only specified for basalts, otherwise default m = 1 - 1/n
Basalt Aquifer,Mualem,1.9,
Interbed,Mualem,,,
Basalt,Mualem,1.9,
Alluvium,Mualem,,,
#Subgrade,Mualem,,,

```

```

#Attenuation Barrier,Mualem,
Clay,Mualem,
#Drain Rock,Mualem,
Operation Gravelly Sand,Mualem,
Waste Gravelly Sand,Mualem,
#
~Initial Conditions Card
Gas Pressure,Aqueous Pressure,
1,
Aqueous Pressure,789004.67,Pa,-6.67,1/m,,, -9793.52,1/m,1,60,1,1,1,98,
#
~Boundary Conditions Card
4,
#
#recharge at top = 1 cm/yr [negative specifies downward]
top,neumann,
1,15,1,1,98,98,1,
0,day,-1.00,cm/yr,
#
#Flow in from the side: v = 1 m/d thus Q = 0.06 m/d
west,neumann,
1,1,1,1,1,20,1,
0,day,0.06,m/day,
#
west,neumann,
#Cell only partly saturated (1 m/2 m) thus Q = 0.03 m/d * (1/2)
1,1,1,1,21,21,1,
0,day,0.03,m/day,
#
east,hydraulic gradient,
#Hold head constant to keep h ~ 5 m at compliance point
60,60,1,1,1,21,1,
0,day,786871.34,Pa,
#
~Surface Flux Card
3,
#check for mass balance
Aqueous Volumetric Flux,m^3/yr,m^3,west,1,1,1,1,1,21,
Aqueous Volumetric Flux,m^3/yr,m^3,east,60,60,1,1,1,21,
Aqueous Volumetric Flux,m^3/yr,m^3,top,1,15,1,1,81,81,
#
~Output Control Card
4,
15,1,88,
15,1,21,
59,1,21,
59,1,15,
1,1,yr,m,8,8,8,
4,
aqueous saturation,,  

aqueous pressure,Pa,  

aqueous moisture content,,  

znc aqueous vol,m/yr,  

2,

```

0, yr,
10000, yr,
5,
aqueous saturation,,
aqueous pressure, Pa,
aqueous moisture content,,
znc aqueous vol, m/yr,
rock/soil type,,

E.2. NATURAL RECHARGE, SURROGATES 1-4 INPUT

-Simulation Title Card

1,
B Pond Lengthwise Cross Section,
WJ McMahon,
CH2M Hill Hanford,
July 23 2001,
10:00 AM PDT,
3,

This input file is the contaminant transport run for the INEEL ICDF simulation

This construction uses the geology developed by Pete Martian
The input parameters are based on PM reports

-Solution Control Card

Restart,restart,
Water w/ Solute Transport,
9,
0,day,20,yr,0.0007,yr,0.02,yr,1.25,8,1.e-6,
20,yr,50,yr,0.02,yr,0.05,yr,1.25,8,1.e-6,
50,yr,100,yr,0.05,yr,0.10,yr,1.25,8,1.e-6,
100,yr,500,yr,0.10,yr,0.50,yr,1.25,8,1.e-6,
500,yr,1000,yr,0.50,yr,2,yr,1.25,8,1.e-6,
1000,yr,5000,yr,2,yr,10,yr,1.25,8,1.e-6,
5000,yr,10000,yr,10,yr,100,yr,1.25,8,1.e-6,
10000,yr,100000,yr,100,yr,1000,yr,1.25,8,1.e-6,
100000,yr,1000000,yr,1000,yr,10000,yr,1.25,8,1.e-6,
8000,
0,

-Grid Card

cartesian,
60,1,98,
X Dimensions::160 m ICDF cell Total X Dimension 320 m
0.,m,6@15,m,5@10,m,2@5,m,2@5,m,
#20 m to screening model compliance point,
2@5,m,1@4.,m,1@3.,m,1@2.,m,1@1.,m,
#190 feet (or 58 m) to edge of landfill cap (less 20 m above)
2@2.,m,1@3,m,1@4.,m,2@6.,m,1@4.,m,2@3.,m,2@2,m,1@1.,m,
#190 feet (or 58 m) plus 20 m (less 58 m above)
2@2.,m,1@3,m,1@4.,m,2@3.,m,1@2,m,1@1.,m,
#190 feet (or 58 m) plus 100 m (less 78 m above)
2@2.,m,1@3,m,2@4.,m,2@5.,m,5@8.,m,1@5.,m,1@4.,m,1@3.,m,1@2,m,1@1.,m,
#One grid block to move last observation point off of boundary
2@1.,m,
Y Dimensions (Y dimension not used)
0.,m,1.,m,
Z Dimensions
#Basalt Aquifer (Total = 76 m, Begin and End Lower 61 m) 9 Rows (Ignore 0)
0.,m,2@12.,m,2@8.,m,2@6.,m,1@4.,m,1@3.,m,1@2.,m,
#Basalt Aquifer Begin First 9 m of Upper 15 m 6 Rows
6@1.5,m,
#Basalt Aquifer Begin and End Upper 6 m
(7 m or 22 ft-note 6 m saturated and 1 m above water table) 6 Rows
1@1,m,1@1,m,1@1,m,1@1,m,1@2,m,

```

#Basalt (16.98 m or 57 ft-note that 1 m added to aquifer layer, 17.98 m = 59
ft)
# 7 Rows
1@2,m,1@2.32,m,1@2.75,m,1@3.25,m,1@3,m,1@2.15,m,1@1.51,m,
#Sedimentary Interbed (7.01 m or 23 ft) 4 Rows
1@1.51,m,1@2,m,1@2,m,1@1.5,m,
#Basalt (39.93 m or 131 ft) 13 Rows
1@1.5,m,1@2,m,1@3,m,1@4,m,1@4,m,1@4.5,m,1@4.5,m,1@4,m,1@4,m,1@3,m,1@2.4,m,
1@1.81,m,1@1.22,m,
#Sedimentary Interbed (4.88 m or 16 ft) 4 Rows
1@1.22,m,1@1.22,m,1@1.22,m,1@1.22,m,
#Basalt (23.47 m or 77 ft) 9 Rows
1@1.22,m,1@2,m,1@3,m,1@3.5,m,1@3.75,m,1@3.5,m,1@3,m,1@2,m,1@1.5,m,
#Sedimentary Interbed (11.89 m or 39 ft) 6 Rows
1@1.5,m,1@1.94,m,1@2.45,m,1@2.45,m,1@2.15,m,1@1.4,m,
#Basalt (26.52 m or 87 ft) 13 Rows
1@1.4,m,1@2,m,1@2,m,1@3,m,1@5,m,1@5,m,1@3,m,1@1.57,m,1@1.2,m,1@1,m,1@0.6,m,
1@0.45,m,1@0.3,m,
#Alluvium changed from 9 to 5 feet (1.52 m or 5 ft) 4 Rows
1@0.30,m,1@0.46,m,1@0.46,m,1@0.30,m,
#Clay Liner (0.91 m or 3 ft) 3 Rows
1@0.30,m,1@0.31,m,1@0.30,m,
#Operations Layer (0.91 m or 3 ft) 3 Rows
1@0.30,m,1@0.31,m,1@0.30,m,
#Waste (10.40 m or 34 ft adjusted to 12.56 m to account for cube vs
trapezoid)
# 11 Rows
1@0.5,m,1@0.5,m,1@1,m,1@1,m,1@1.64,m,1@1.64,m,1@1.64,m,1@1.64,m,1@1,m,1
@1,m,

```

-Rock/Soil Zonation Card

```

14,
#Lower 61 m of Basalt Aquifer
Basalt Aquifer,1,60,1,1,1,9,
#Begin First 9 m of Upper 15 m of Basalt Aquifer
Basalt Aquifer,1,60,1,1,10,15,
#Upper 6 m of Basalt Aquifer
Basalt Aquifer,1,60,1,1,16,21,
#Lowest Vadose Basalt Layer
Basalt,1,60,1,1,22,28,
Interbed,1,60,1,1,29,32,
Basalt,1,60,1,1,33,45,
Interbed,1,60,1,1,46,49,
Basalt,1,60,1,1,50,58,
Interbed,1,60,1,1,59,64,
Basalt,1,60,1,1,65,77,
Alluvium,1,60,1,1,78,81,
Clay,1,60,1,1,82,84,
Operation Gravelly Sand,1,60,1,1,85,87,
Waste Gravelly Sand,1,60,1,1,88,98,

```

-Inactive Nodes Card

```

#Integer,
1,
16,60,1,1,22,98,

```

-Mechanical Properties Card

```

#Particle density = 2650 kg/m^3 except for clay and old alluvium
#Subgrade, attenuation barrier, and drain rock used in earlier models but
#not used here
#Basalt and interbed properties from P. Martian Screening Model
Basalt Aquifer,,,0.06,0.06,,,Millington and Quirk,
Interbed,,,0.487,0.487,,,Millington and Quirk,
Basalt,,,0.05,0.05,,,Millington and Quirk,
#
#Old Alluvium characteristics from Geotech report measurements
# sat. moisture content (0.422, 0.426); dry bulk density (1.60, 1.64 g/cm^3)
# particle density = 1.62 g/cm^3/(1-0.424) = 2.8125 g/cm^3
Alluvium,2812.5,kg/m^3,0.424,0.424,,,Millington and Quirk,
#Attenuation Barrier,,,0.400,0.400,,,Millington and Quirk,
#Clay characteristics per discussion with J. Dehner
Clay,2600,kg/m^3,0.390,0.390,,,Millington and Quirk,
#Drain Rock,,,0.400,0.400,,,Millington and Quirk,
Operation Gravelly Sand,,,0.275,0.275,,,Millington and Quirk,
#Operation Gravelly Sand dry bulk density = 120 lb/ft^3 (per J. Dehner)
#120 lb/ft^3*0.4536 kg/lb*1 ft^3/(0.3048 m/ft)^3 = 1922.25 kg/m^3
#Porosity Operation Gravelly Sand = 1-(1922.25/2650)= 0.275
Waste Gravelly Sand,,,0.266,0.266,,,Millington and Quirk,
#Waste Gravelly Sand dry bulk density = 121.5 lb/ft^3 (per J. Dehner)
#121.5 lb/ft^3*0.4536 kg/lb*1 ft^3/(0.3048 m)^3 = 1946.28 kg/m^3
#Porosity Waste Gravelly Sand = 1-(1946.28/2650)= 0.266

```

~Hydraulic Properties Card

```

#Properties from P. Martian Screening Model except old alluvium
Basalt Aquifer,9.00e+01,darcy,,,3.00e-01,darcy,
Interbed,6.7e-5,hc:cm/s,,,6.7e-5,hc:cm/s,
Basalt,9.00e+01,darcy,,,3.00e-01,darcy,
#Old Alluvium characteristics from Geotech report measurements
# sat. hydraulic conductivity (1.2e-07 cm/s, 6.2e-08 cm/s, 7.1e-08 cm/s)
Alluvium,1.2e-07,hc:cm/s,,,1.2e-07,hc:cm/s,
#Subgrade,1e-04,hc:cm/s,,,1e-04,hc:cm/s,
#Attenuation Barrier,1e-07,hc:cm/s,,,1e-07,hc:cm/s,
Clay,1e-07,hc:cm/s,,,1e-07,hc:cm/s,
#Drain Rock,3.0e-01,hc:cm/s,,,3.0e-01,hc:cm/s,
Operation Gravelly Sand,1e-04,hc:cm/s,,,1e-04,hc:cm/s,
Waste Gravelly Sand,1e-03,hc:cm/s,,,1e-03,hc:cm/s,

```

~Saturation Function Card

```

#Parameters from P. Martian Screening Model except old alluvium
#alpha, n, theta R, m
#m only specified for basalts, otherwise default m = 1 - 1/n
Basalt Aquifer,Nonhysteretic van Genuchten,4.0,1/m,4.5,0.0002,0.7777778,
Interbed,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.142,,,
Basalt,Nonhysteretic van Genuchten,4.0,1/m,4.5,0.0002,0.7777778,
#Old Alluvium characteristics from RETC fitting of Geotech report
measurements
Alluvium,Nonhysteretic van Genuchten,0.595,1/m,1.09,0.142,,,
#Subgrade,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.142,,,
#Attenuation Barrier,Nonhysteretic van Genuchten,0.800,1/m,1.090,0.07,,,
Clay,Nonhysteretic van Genuchten,0.800,1/m,1.109,0.07,,,
#Drain Rock,Nonhysteretic van Genuchten,493,1/m,2.190,0.005,,,
Operation Gravelly Sand,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.083,,,
Waste Gravelly Sand,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.072,,,
#

```

```

~Aqueous Relative Permeability Card
#m only specified for basalts, otherwise default m = 1 - 1/n
Basalt Aquifer,Mualem,1.9,
Interbed,Mualem.,
Basalt,Mualem,1.9,
Alluvium,Mualem.,
#Subgrade,Mualem.,
#Attenuation Barrier,Mualem.,
Clay,Mualem.,
#Drain Rock,Mualem.,
Operation Gravelly Sand,Mualem.,
Waste Gravelly Sand,Mualem.,
#
~Solute/Fluid Interactions Card
4,
H-3,conventional,1.0e-09,m^2/s,noncontinuous,,
I-129,conventional,1.0e-09,m^2/s,noncontinuous,,
Tc-99,conventional,1.0e-09,m^2/s,noncontinuous,,
U-235,conventional,1.0e-09,m^2/s,noncontinuous,,
#Np-237,conventional,1.0e-09,m^2/s,noncontinuous,,
#Sr-90,conventional,1.0e-09,m^2/s,noncontinuous,,
#Zn-65,conventional,1.0e-09,m^2/s,noncontinuous,,
#Eu-155,conventional,1.0e-09,m^2/s,noncontinuous,,
0,
#
~Solute/Porous Media Interaction Card
Basalt Aquifer,6.0,m,3.0,m,
H-3,0.0,cm^3/g,
I-129,0.0,cm^3/g,
Tc-99,0.008,cm^3/g,
U-235,0.24,cm^3/g,
#Np-237,0.32,cm^3/g,
#Sr-90,0.48,cm^3/g,
#Zn-65,0.64,cm^3/g,
#Eu-155,314,cm^3/g,
#
Interbed,5.0,m,0,m,
H-3,0.0,cm^3/g,
I-129,0.0,cm^3/g,
Tc-99,0.2,cm^3/g,
U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
#Sr-90,24.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
#Eu-155,314,cm^3/g,
#
Basalt,5.0,m,0,m,
H-3,0.0,cm^3/g,
I-129,0.0,cm^3/g,
Tc-99,0.0,cm^3/g,
U-235,0.0,cm^3/g,
#Np-237,0.0,cm^3/g,
#Sr-90,0.0,cm^3/g,
#Zn-65,0.0,cm^3/g,
#Eu-155,314,cm^3/g,
#
#Subgrade,5.0,m,0,m,

```

```

#
Alluvium,5.0,m,0,m,
H-3,0.0,cm^3/g,
I-129,0.0,cm^3/g,
Tc-99,0.2,cm^3/g,
U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
#Sr-90,24.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
#Eu-155,314,cm^3/g,
#
#Attenuation Barrier,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,1.0,cm^3/g,
#Tc-99,1.0,cm^3/g,
#U-235,63.0,cm^3/g,
#Np-237,55.0,cm^3/g,
#Sr-90,200.0,cm^3/g,
#Zn-65,2400.0,cm^3/g,
#Eu-155,314,cm^3/g,
#
Clay,5.0,m,0,m,
H-3,0.0,cm^3/g,
I-129,1.0,cm^3/g,
Tc-99,1.0,cm^3/g,
U-235,63.0,cm^3/g,
#Np-237,55.0,cm^3/g,
#Sr-90,200.0,cm^3/g,
#Zn-65,2400.0,cm^3/g,
#Eu-155,314,cm^3/g,
#
#Drain Rock,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.2,cm^3/g,
#U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
#Sr-90,24.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
#Eu-155,314,cm^3/g,
#
Operation Gravelly Sand,5.0,m,0,m,
H-3,0.0,cm^3/g,
I-129,0.0,cm^3/g,
Tc-99,0.2,cm^3/g,
U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
#Sr-90,24.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
#Eu-155,314,cm^3/g,
#
Waste Gravelly Sand,5.0,m,0,m,
H-3,0.0,cm^3/g,
I-129,0.0,cm^3/g,
Tc-99,0.2,cm^3/g,
U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,

```

```

#Sr-90,12.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
#Eu-155,314,cm^3/g,
#
~Initial Conditions Card
Gas Pressure,Aqueous Pressure,
9,
Aqueous Pressure,,,,,,,,,1,60,1,1,1,98,
Solute Volume Overwrite,H-3,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,I-129,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Tc-99,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,U-235,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,Np-237,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,Sr-90,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,Zn-65,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,Eu-155,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#
Solute Volume Overwrite,H-3,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,I-129,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Tc-99,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,U-235,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,Np-237,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,Sr-90,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,Zn-65,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,Eu-155,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,

~Boundary Conditions Card
4,
#
top,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#0.01 m/yr * 1.74 ICDF Recharge Ratio = 0.0174 m/yr
1,15,1,1,98,98,1,
0,day,-0.0174,m/yr,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
west,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
1,1,1,1,20,1,
0,day,0.06,m/day,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
west,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
1,1,1,1,21,1,
0,day,0.03,m/day,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
east,hydraulic gradient,outflow,outflow,outflow,outflow,
#Hold head constant to keep h ~ 5 m at compliance point
60,60,1,1,1,21,1,

```

```

0,day,786871.34,Pa,,,,,,,,,,,
#
~Surface Flux Card
50,
Aqueous Volumetric Flux,m^3/yr,m^3,bottom,1,15,1,1,82,82,
Solute Flux,H-3,1/yr,,bottom,1,15,1,1,82,82,
Solute Flux,I-129,1/yr,,bottom,1,15,1,1,82,82,
Solute Flux,Tc-99,1/yr,,bottom,1,15,1,1,82,82,
Solute Flux,U-235,1/yr,,bottom,1,15,1,1,82,82,
#Solute Flux,Np-237,1/yr,,bottom,1,15,1,1,82,82,
#Solute Flux,Sr-90,1/yr,,bottom,1,15,1,1,82,82,
#Solute Flux,Zn-65,1/yr,,bottom,1,15,1,1,82,82,
#Solute Flux,Eu-155,1/yr,,bottom,1,15,1,1,82,82,
#
Aqueous Volumetric Flux,m^3/yr,m^3,bottom,1,15,1,1,22,22,
Solute Flux,H-3,1/yr,,bottom,1,15,1,1,22,22,
Solute Flux,I-129,1/yr,,bottom,1,15,1,1,22,22,
Solute Flux,Tc-99,1/yr,,bottom,1,15,1,1,22,22,
Solute Flux,U-235,1/yr,,bottom,1,15,1,1,22,22,
#Solute Flux,Np-237,1/yr,,bottom,1,15,1,1,22,22,
#Solute Flux,Sr-90,1/yr,,bottom,1,15,1,1,22,22,
#Solute Flux,Zn-65,1/yr,,bottom,1,15,1,1,22,22,
#Solute Flux,Eu-155,1/yr,,bottom,1,15,1,1,22,22,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,21,21,1,1,10,21,
Solute Flux,H-3,1/yr,,west,21,21,1,1,10,21,
Solute Flux,I-129,1/yr,,west,21,21,1,1,10,21,
Solute Flux,Tc-99,1/yr,,west,21,21,1,1,10,21,
Solute Flux,U-235,1/yr,,west,21,21,1,1,10,21,
#Solute Flux,Np-237,1/yr,,west,21,21,1,1,10,21,
#Solute Flux,Sr-90,1/yr,,west,21,21,1,1,10,21,
#Solute Flux,Zn-65,1/yr,,west,21,21,1,1,10,21,
#Solute Flux,Eu-155,1/yr,,west,21,21,1,1,10,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,21,21,1,1,17,21,
Solute Flux,H-3,1/yr,,west,21,21,1,1,17,21,
Solute Flux,I-129,1/yr,,west,21,21,1,1,17,21,
Solute Flux,Tc-99,1/yr,,west,21,21,1,1,17,21,
Solute Flux,U-235,1/yr,,west,21,21,1,1,17,21,
#Solute Flux,Np-237,1/yr,,west,21,21,1,1,17,21,
#Solute Flux,Sr-90,1/yr,,west,21,21,1,1,17,21,
#Solute Flux,Zn-65,1/yr,,west,21,21,1,1,17,21,
#Solute Flux,Eu-155,1/yr,,west,21,21,1,1,17,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,33,33,1,1,10,21,
Solute Flux,H-3,1/yr,,west,33,33,1,1,10,21,
Solute Flux,I-129,1/yr,,west,33,33,1,1,10,21,
Solute Flux,Tc-99,1/yr,,west,33,33,1,1,10,21,
Solute Flux,U-235,1/yr,,west,33,33,1,1,10,21,
#Solute Flux,Np-237,1/yr,,west,33,33,1,1,10,21,
#Solute Flux,Sr-90,1/yr,,west,33,33,1,1,10,21,
#Solute Flux,Zn-65,1/yr,,west,33,33,1,1,10,21,
#Solute Flux,Eu-155,1/yr,,west,33,33,1,1,10,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,33,33,1,1,17,21,
Solute Flux,H-3,1/yr,,west,33,33,1,1,17,21,
Solute Flux,I-129,1/yr,,west,33,33,1,1,17,21,

```

```

Solute Flux,Tc-99,1/yr.,west,33,33,1,1,17,21,
Solute Flux,U-235,1/yr.,west,33,33,1,1,17,21,
#Solute Flux,Np-237,1/yr.,west,33,33,1,1,17,21,
#Solute Flux,Sr-90,1/yr.,west,33,33,1,1,17,21,
#Solute Flux,Zn-65,1/yr.,west,33,33,1,1,17,21,
#Solute Flux,Eu-155,1/yr.,west,33,33,1,1,17,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,41,41,1,1,10,21,
Solute Flux,H-3,1/yr.,west,41,41,1,1,10,21,
Solute Flux,I-129,1/yr.,west,41,41,1,1,10,21,
Solute Flux,Tc-99,1/yr.,west,41,41,1,1,10,21,
Solute Flux,U-235,1/yr.,west,41,41,1,1,10,21,
#Solute Flux,Np-237,1/yr.,west,41,41,1,1,10,21,
#Solute Flux,Sr-90,1/yr.,west,41,41,1,1,10,21,
#Solute Flux,Zn-65,1/yr.,west,41,41,1,1,10,21,
#Solute Flux,Eu-155,1/yr.,west,41,41,1,1,10,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,41,41,1,1,17,21,
Solute Flux,H-3,1/yr.,west,41,41,1,1,17,21,
Solute Flux,I-129,1/yr.,west,41,41,1,1,17,21,
Solute Flux,Tc-99,1/yr.,west,41,41,1,1,17,21,
Solute Flux,U-235,1/yr.,west,41,41,1,1,17,21,
#Solute Flux,Np-237,1/yr.,west,41,41,1,1,17,21,
#Solute Flux,Sr-90,1/yr.,west,41,41,1,1,17,21,
#Solute Flux,Zn-65,1/yr.,west,41,41,1,1,17,21,
#Solute Flux,Eu-155,1/yr.,west,41,41,1,1,17,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,58,58,1,1,10,21,
Solute Flux,H-3,1/yr.,west,58,58,1,1,10,21,
Solute Flux,I-129,1/yr.,west,58,58,1,1,10,21,
Solute Flux,Tc-99,1/yr.,west,58,58,1,1,10,21,
Solute Flux,U-235,1/yr.,west,58,58,1,1,10,21,
#Solute Flux,Np-237,1/yr.,west,58,58,1,1,10,21,
#Solute Flux,Sr-90,1/yr.,west,58,58,1,1,10,21,
#Solute Flux,Zn-65,1/yr.,west,58,58,1,1,10,21,
#Solute Flux,Eu-155,1/yr.,west,58,58,1,1,10,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,58,58,1,1,17,21,
Solute Flux,H-3,1/yr.,west,58,58,1,1,17,21,
Solute Flux,I-129,1/yr.,west,58,58,1,1,17,21,
Solute Flux,Tc-99,1/yr.,west,58,58,1,1,17,21,
Solute Flux,U-235,1/yr.,west,58,58,1,1,17,21,
#Solute Flux,Np-237,1/yr.,west,58,58,1,1,17,21,
#Solute Flux,Sr-90,1/yr.,west,58,58,1,1,17,21,
#Solute Flux,Zn-65,1/yr.,west,58,58,1,1,17,21,
#Solute Flux,Eu-155,1/yr.,west,58,58,1,1,17,21,
#
~Output Control Card
48,
21,1,10,
21,1,11,
21,1,12,
21,1,13,
21,1,14,
21,1,15,
21,1,16,
21,1,17,

```

21,1,18,
21,1,19,
21,1,20,
21,1,21,
33,1,10,
33,1,11,
33,1,12,
33,1,13,
33,1,14,
33,1,15,
33,1,16,
33,1,17,
33,1,18,
33,1,19,
33,1,20,
33,1,21,
41,1,10,
41,1,11,
41,1,12,
41,1,13,
41,1,14,
41,1,15,
41,1,16,
41,1,17,
41,1,18,
41,1,19,
41,1,20,
41,1,21,
58,1,10,
58,1,11,
58,1,12,
58,1,13,
58,1,14,
58,1,15,
58,1,16,
58,1,17,
58,1,18,
58,1,19,
58,1,20,
58,1,21,
1,1,yr,m,8,8,8,
8,
aqueous saturation,,
aqueous pressure,Pa,
aqueous moisture content,,
znc aqueous vol,m/yr,
solute aqueous concentration,H-3,,
solute aqueous concentration,I-129,,
solute aqueous concentration,Tc-99,,
solute aqueous concentration,U-235,,
12,
#1,yr,
10,yr,
100,yr,
200,yr,
500,yr,
1000,yr,

1200, yr,
1500, yr,
2000, yr,
#2500, yr,
5000, yr,
10000, yr,
#20000, yr,
50000, yr,
100000, yr,
#200000, yr,
8,
aqueous saturation,,
aqueous pressure, Pa,
aqueous moisture content,,
znc aqueous vol,m/yr,
solute aqueous concentration,H-3,,
solute aqueous concentration,I-129,,
solute aqueous concentration,Tc-99,,
solute aqueous concentration,U-235,,
rock/soil type.,

E.3. NATURAL RECHARGE, SURROGATES 4 – 8 INPUT

~Simulation Title Card
1,
B Pond Lengthwise Cross Section,
WJ McMahon,
CH2M Hill Hanford,
July 23 2001,
10:00 AM PDT,
3,
This input file is the contaminant transport run for the INEEL ICDF simulation
This construction uses the geology developed by Pete Martian
The input parameters are based on PM reports

~Solution Control Card

Restart,restart,
Water w/ Solute Transport,
9,
0,day,20,yr,0.0007,yr,0.02,yr,1.25,8,1.e-6,
20,yr,50,yr,0.02,yr,0.05,yr,1.25,8,1.e-6,
50,yr,100,yr,0.05,yr,0.10,yr,1.25,8,1.e-6,
100,yr,500,yr,0.10,yr,0.50,yr,1.25,8,1.e-6,
500,yr,1000,yr,0.50,yr,2,yr,1.25,8,1.e-6,
1000,yr,5000,yr,2,yr,10,yr,1.25,8,1.e-6,
5000,yr,10000,yr,10,yr,100,yr,1.25,8,1.e-6,
10000,yr,100000,yr,100,yr,1000,yr,1.25,8,1.e-6,
100000,yr,1000000,yr,1000,yr,10000,yr,1.25,8,1.e-6,
8000,
0,

~Grid Card

cartesian,
60,1,98,
X Dimensions::160 m ICDF cell Total X Dimension 320 m
0.,m,6@15,m,5@10,m,2@5,m,2@5,m,
#20 m to screening model compliance point,
2@5,m,1@4.,m,1@3.,m,1@2.,m,1@1.,m,
#190 feet (or 58 m) to edge of landfill cap (less 20 m above)
2@2.,m,1@3,m,1@4.,m,2@6.,m,1@4.,m,2@3.,m,2@2,m,1@1.,m,
#190 feet (or 58 m) plus 20 m (less 58 m above)
2@2.,m,1@3,m,1@4.,m,2@3.,m,1@2,m,1@1.,m,
#190 feet (or 58 m) plus 100 m (less 78 m above)
2@2.,m,1@3,m,2@4.,m,2@5.,m,5@8.,m,1@5.,m,1@4.,m,1@3.,m,1@2,m,1@1.,m,
#One grid block to move last observation point off of boundary
2@1.,m,
Y Dimensions (Y dimension not used)
0.,m,1.,m,
Z Dimensions
#Basalt Aquifer (Total = 76 m, Begin and End Lower 61 m) 9 Rows (Ignore 0)
0.,m,2@12.,m,2@8.,m,2@6.,m,1@4.,m,1@3.,m,1@2.,m,
#Basalt Aquifer Begin First 9 m of Upper 15 m 6 Rows
6@1.5,m,
#Basalt Aquifer Begin and End Upper 6 m
(7 m or 22 ft-note 6 m saturated and 1 m above water table) 6 Rows
1@1,m,1@1,m,1@1,m,1@1,m,1@1,m,1@2,m,

```

#Basalt (16.98 m or 57 ft-note that 1 m added to aquifer layer, 17.98 m = 59
ft)
# 7 Rows
1@2,m,1@2.32,m,1@2.75,m,1@3.25,m,1@3,m,1@2.15,m,1@1.51,m,
#Sedimentary Interbed (7.01 m or 23 ft) 4 Rows
1@1.51,m,1@2,m,1@2,m,1@1.5,m,
#Basalt (39.93 m or 131 ft) 13 Rows
1@1.5,m,1@2,m,1@3,m,1@4,m,1@4,m,1@4.5,m,1@4.5,m,1@4,m,1@4,m,1@3,m,1@2.4,m,
1@1.81,m,1@1.22,m,
#Sedimentary Interbed (4.88 m or 16 ft) 4 Rows
1@1.22,m,1@1.22,m,1@1.22,m,1@1.22,m,
#Basalt (23.47 m or 77 ft) 9 Rows
1@1.22,m,1@2,m,1@3,m,1@3.5,m,1@3.75,m,1@3.5,m,1@2,m,1@1.5,m,
#Sedimentary Interbed (11.89 m or 39 ft) 6 Rows
1@1.5,m,1@1.94,m,1@2.45,m,1@2.45,m,1@2.15,m,1@1.4,m,
#Basalt (26.52 m or 87 ft) 13 Rows
1@1.4,m,1@2,m,1@2,m,1@3,m,1@5,m,1@5,m,1@3,m,1@1.57,m,1@1.2,m,1@1,m,1@0.6,m,
1@0.45,m,1@0.3,m,
#Alluvium changed from 9 to 5 feet (1.52 m or 5 ft) 4 Rows
1@0.30,m,1@0.46,m,1@0.46,m,1@0.30,m,
#Clay Liner (0.91 m or 3 ft) 3 Rows
1@0.30,m,1@0.31,m,1@0.30,m,
#Operations Layer (0.91 m or 3 ft) 3 Rows
1@0.30,m,1@0.31,m,1@0.30,m,
#Waste (10.40 m or 34 ft adjusted to 12.56 m to account for cube vs
trapezoid)
# 11 Rows
1@0.5,m,1@0.5,m,1@1,m,1@1,m,1@1.64,m,1@1.64,m,1@1.64,m,1@1.64,m,1@1,m,1
@1,m,

```

~Rock/Soil Zonation Card

```

14,
#Lower 61 m of Basalt Aquifer
Basalt Aquifer,1,60,1,1,1,9,
#Begin First 9 m of Upper 15 m of Basalt Aquifer
Basalt Aquifer,1,60,1,1,10,15,
#Upper 6 m of Basalt Aquifer
Basalt Aquifer,1,60,1,1,16,21,
#Lowest Vadose Basalt Layer
Basalt,1,60,1,1,22,28,
Interbed,1,60,1,1,29,32,
Basalt,1,60,1,1,33,45,
Interbed,1,60,1,1,46,49,
Basalt,1,60,1,1,50,58,
Interbed,1,60,1,1,59,64,
Basalt,1,60,1,1,65,77,
Alluvium,1,60,1,1,78,81,
Clay,1,60,1,1,82,84,
Operation Gravelly Sand,1,60,1,1,85,87,
Waste Gravelly Sand,1,60,1,1,88,98,

```

~Inactive Nodes Card

```

#Integer,
1,
16,60,1,1,22,98,

```

~Mechanical Properties Card

```

#Particle density = 2650 kg/m^3 except for clay and old alluvium
#Subgrade, attenuation barrier, and drain rock used in earlier models but
#not used here
#Basalt and interbed properties from P. Martian Screening Model
Basalt Aquifer,,,0.06,0.06,,,Millington and Quirk,
Interbed,,,0.487,0.487,,,Millington and Quirk,
Basalt,,,0.05,0.05,,,Millington and Quirk,
#
#Old Alluvium characteristics from Geotech report measurements
# sat. moisture content (0.422, 0.426); dry bulk density (1.60, 1.64 g/cm^3)
# particle density = 1.62 g/cm^3/(1-0.424) = 2.8125 g/cm^3
Alluvium,2812.5,kg/m^3,0.424,0.424,,,Millington and Quirk,
#Attenuation Barrier,,,0.400,0.400,,,Millington and Quirk,
#Clay characteristics per discussion with J. Dehner
Clay,2600,kg/m^3,0.390,0.390,,,Millington and Quirk,
#Drain Rock,,,0.400,0.400,,,Millington and Quirk,
Operation Gravelly Sand,,,0.275,0.275,,,Millington and Quirk,
#Operation Gravelly Sand dry bulk density = 120 lb/ft^3 (per J. Dehner)
#120 lb/ft^3*0.4536 kg/lb*1 ft^3/(0.3048 m/ft)^3 = 1922.25 kg/m^3
#Porosity Operation Gravelly Sand = 1-(1922.25/2650)= 0.275
Waste Gravelly Sand,,,0.266,0.266,,,Millington and Quirk,
#Waste Gravelly Sand dry bulk density = 121.5 lb/ft^3 (per J. Dehner)
#121.5 lb/ft^3*0.4536 kg/lb*1 ft^3/(0.3048 m)^3 = 1946.28 kg/m^3
#Porosity Waste Gravelly Sand = 1-(1946.28/2650)= 0.266

```

~Hydraulic Properties Card

```

#Properties from P. Martian Screening Model except old alluvium
Basalt Aquifer,9.00e+01,darcy,,,3.00e-01,darcy,
Interbed,6.7e-5,hc:cm/s,,,6.7e-5,hc:cm/s,
Basalt,9.00e+01,darcy,,,3.00e-01,darcy,
#Old Alluvium characteristics from Geotech report measurements
# sat. hydraulic conductivity (1.2e-07 cm/s, 6.2e-08 cm/s, 7.1e-08 cm/s)
Alluvium,1.2e-07,hc:cm/s,,,1.2e-07,hc:cm/s,
#Subgrade,1e-04,hc:cm/s,,,1e-04,hc:cm/s,
#Attenuation Barrier,1e-07,hc:cm/s,,,1e-07,hc:cm/s,
Clay,1e-07,hc:cm/s,,,1e-07,hc:cm/s,
#Drain Rock,3.0e-01,hc:cm/s,,,3.0e-01,hc:cm/s,
Operation Gravelly Sand,1e-04,hc:cm/s,,,1e-04,hc:cm/s,
Waste Gravelly Sand,1e-03,hc:cm/s,,,1e-03,hc:cm/s,

```

~Saturation Function Card

```

#Parameters from P. Martian Screening Model except old alluvium
#alpha, n, theta R, m
#m only specified for basalts, otherwise default m = 1 - 1/n
Basalt Aquifer,Nonhysteretic van Genuchten,4.0,1/m,4.5,0.0002,0.7777778,
Interbed,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.142.,
Basalt,Nonhysteretic van Genuchten,4.0,1/m,4.5,0.0002,0.7777778,
#Old Alluvium characteristics from RETC fitting of Geotech report
measurements
Alluvium,Nonhysteretic van Genuchten,0.595,1/m,1.09,0.142.,
#Subgrade,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.142.,
#Attenuation Barrier,Nonhysteretic van Genuchten,0.800,1/m,1.090,0.07.,
Clay,Nonhysteretic van Genuchten,0.800,1/m,1.109,0.07.,
#Drain Rock,Nonhysteretic van Genuchten,493,1/m,2.190,0.005.,
Operation Gravelly Sand,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.083.,
Waste Gravelly Sand,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.072.,
#

```

```

~Aqueous Relative Permeability Card
#m only specified for basalts, otherwise default m = 1 - 1/n
Basalt Aquifer,Mualem,1.9,
Interbed,Mualem.,
Basalt,Mualem,1.9,
Alluvium,Mualem.,
#Subgrade,Mualem.,
#Attenuation Barrier,Mualem.,
Clay,Mualem.,
#Drain Rock,Mualem.,
Operation Gravelly Sand,Mualem.,
Waste Gravelly Sand,Mualem.,
#
~Solute/Fluid Interactions Card
4,
#H-3,conventional,1.0e-09,m^2/s,noncontinuous...
#I-129,conventional,1.0e-09,m^2/s,noncontinuous...
#Tc-99,conventional,1.0e-09,m^2/s,noncontinuous...
#U-235,conventional,1.0e-09,m^2/s,noncontinuous...
Np-237,conventional,1.0e-09,m^2/s,noncontinuous...
Sr-90,conventional,1.0e-09,m^2/s,noncontinuous...
Zn-65,conventional,1.0e-09,m^2/s,noncontinuous...
Eu-155,conventional,1.0e-09,m^2/s,noncontinuous...
0,
#
~Solute/Porous Media Interaction Card
Basalt Aquifer,6.0,m,3.0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.008,cm^3/g,
#U-235,0.24,cm^3/g,
Np-237,0.32,cm^3/g,
Sr-90,0.48,cm^3/g,
Zn-65,0.64,cm^3/g,
Eu-155,314,cm^3/g,
#
Interbed,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.2,cm^3/g,
#U-235,6.0,cm^3/g,
Np-237,8.0,cm^3/g,
Sr-90,12.0,cm^3/g,
Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
Basalt,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.0,cm^3/g,
#U-235,0.0,cm^3/g,
Np-237,0.0,cm^3/g,
Sr-90,0.0,cm^3/g,
Zn-65,0.0,cm^3/g,
Eu-155,0.0,cm^3/g,
#

```

```

#Subgrade,5.0,m,0,m,
#
Alluvium,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.2,cm^3/g,
#U-235,6.0,cm^3/g,
Np-237,8.0,cm^3/g,
Sr-90,24.0,cm^3/g,
Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
#Attenuation Barrier,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,1.0,cm^3/g,
#Tc-99,1.0,cm^3/g,
#U-235,63.0,cm^3/g,
#Np-237,55.0,cm^3/g,
#Sr-90,200.0,cm^3/g,
#Zn-65,2400.0,cm^3/g,
#Eu-155,340,cm^3/g,
#
Clay,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,1.0,cm^3/g,
#Tc-99,1.0,cm^3/g,
#U-235,63.0,cm^3/g,
Np-237,55.0,cm^3/g,
Sr-90,200.0,cm^3/g,
Zn-65,2400.0,cm^3/g,
Eu-155,340,cm^3/g,
#
#Drain Rock,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.2,cm^3/g,
#U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
#Sr-90,24.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
#Eu-155,340,cm^3/g,
#
Operation Gravelly Sand,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.2,cm^3/g,
#U-235,6.0,cm^3/g,
Np-237,8.0,cm^3/g,
Sr-90,12.0,cm^3/g,
Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
Waste Gravelly Sand,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.2,cm^3/g,
#U-235,6.0,cm^3/g,

```

```

Np-237,8.0,cm^3/g,
Sr-90,12.0,cm^3/g,
Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
~Initial Conditions Card
Gas Pressure,Aqueous Pressure,
9,
Aqueous Pressure,,1,60,1,1,1,83,
#Solute Volume Overwrite,H-3,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,I-129,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,Tc-99,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,U-235,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Np-237,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Sr-90,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Zn-65,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Eu-155,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
#
#Solute Volume Overwrite,H-3,2.0e+03,1/m^3,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,I-129,2.0e+03,1/m^3,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,Tc-99,2.0e+03,1/m^3,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,U-235,2.0e+03,1/m^3,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Np-237,1946.28,1/m^3,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Sr-90,1946.28,1/m^3,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Zn-65,1946.28,1/m^3,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Eu-155,1946.28,1/m^3,0,,0,,1,15,1,1,88,98,
#
~Boundary Conditions Card
4,
#
top,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#0.01 m/yr * 1.74 ICDF Recharge Ratio = 0.0174 m/yr
1,15,1,1,98,98,1,
0,day,-0.0174,m/yr,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
west,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
1,1,1,1,1,20,1,
0,day,0.06,m/day,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
west,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
1,1,1,1,21,21,1,
0,day,0.03,m/day,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
east,hydraulic gradient,outflow,outflow,outflow,outflow,
#Hold head constant to keep h ~ 5 m at compliance point

```

```

60,60,1,1,1,21,1,
0,day,786871.34,Pa,.....  

#
~Surface Flux Card  

50,  

Aqueous Volumetric Flux,m^3/yr,m^3,bottom,1,15,1,1,82,82,  

#Solute Flux,H-3,1/yr,,bottom,1,15,1,1,82,82,  

#Solute Flux,I-129,1/yr,,bottom,1,15,1,1,82,82,  

#Solute Flux,Tc-99,1/yr,,bottom,1,15,1,1,82,82,  

#Solute Flux,U-235,1/yr,,bottom,1,15,1,1,82,82,  

Solute Flux,Np-237,1/yr,,bottom,1,15,1,1,82,82,  

Solute Flux,Sr-90,1/yr,,bottom,1,15,1,1,82,82,  

Solute Flux,Zn-65,1/yr,,bottom,1,15,1,1,82,82,  

Solute Flux,Eu-155,1/yr,,bottom,1,15,1,1,82,82,  

#  

Aqueous Volumetric Flux,m^3/yr,m^3,bottom,1,15,1,1,22,22,  

#Solute Flux,H-3,1/yr,,bottom,1,15,1,1,22,22,  

#Solute Flux,I-129,1/yr,,bottom,1,15,1,1,22,22,  

#Solute Flux,Tc-99,1/yr,,bottom,1,15,1,1,22,22,  

#Solute Flux,U-235,1/yr,,bottom,1,15,1,1,22,22,  

Solute Flux,Np-237,1/yr,,bottom,1,15,1,1,22,22,  

Solute Flux,Sr-90,1/yr,,bottom,1,15,1,1,22,22,  

Solute Flux,Zn-65,1/yr,,bottom,1,15,1,1,22,22,  

Solute Flux,Eu-155,1/yr,,bottom,1,15,1,1,22,22,  

#  

Aqueous Volumetric Flux,m^3/yr,m^3,west,21,21,1,1,10,21,  

#Solute Flux,H-3,1/yr,,west,21,21,1,1,10,21,  

#Solute Flux,I-129,1/yr,,west,21,21,1,1,10,21,  

#Solute Flux,Tc-99,1/yr,,west,21,21,1,1,10,21,  

#Solute Flux,U-235,1/yr,,west,21,21,1,1,10,21,  

Solute Flux,Np-237,1/yr,,west,21,21,1,1,10,21,  

Solute Flux,Sr-90,1/yr,,west,21,21,1,1,10,21,  

Solute Flux,Zn-65,1/yr,,west,21,21,1,1,10,21,  

Solute Flux,Eu-155,1/yr,,west,21,21,1,1,10,21,  

#  

Aqueous Volumetric Flux,m^3/yr,m^3,west,21,21,1,1,17,21,  

#Solute Flux,H-3,1/yr,,west,21,21,1,1,17,21,  

#Solute Flux,I-129,1/yr,,west,21,21,1,1,17,21,  

#Solute Flux,Tc-99,1/yr,,west,21,21,1,1,17,21,  

#Solute Flux,U-235,1/yr,,west,21,21,1,1,17,21,  

Solute Flux,Np-237,1/yr,,west,21,21,1,1,17,21,  

Solute Flux,Sr-90,1/yr,,west,21,21,1,1,17,21,  

Solute Flux,Zn-65,1/yr,,west,21,21,1,1,17,21,  

Solute Flux,Eu-155,1/yr,,west,21,21,1,1,17,21,  

#  

Aqueous Volumetric Flux,m^3/yr,m^3,west,33,33,1,1,10,21,  

#Solute Flux,H-3,1/yr,,west,33,33,1,1,10,21,  

#Solute Flux,I-129,1/yr,,west,33,33,1,1,10,21,  

#Solute Flux,Tc-99,1/yr,,west,33,33,1,1,10,21,  

#Solute Flux,U-235,1/yr,,west,33,33,1,1,10,21,  

Solute Flux,Np-237,1/yr,,west,33,33,1,1,10,21,  

Solute Flux,Sr-90,1/yr,,west,33,33,1,1,10,21,  

Solute Flux,Zn-65,1/yr,,west,33,33,1,1,10,21,  

Solute Flux,Eu-155,1/yr,,west,33,33,1,1,10,21,  

#  

Aqueous Volumetric Flux,m^3/yr,m^3,west,33,33,1,1,17,21,  

#Solute Flux,H-3,1/yr,,west,33,33,1,1,17,21,

```

```

#Solute Flux,I-129,1/yr.,west,33,33,1,1,17,21,
#Solute Flux,Tc-99,1/yr.,west,33,33,1,1,17,21,
#Solute Flux,U-235,1/yr.,west,33,33,1,1,17,21,
Solute Flux,Np-237,1/yr.,west,33,33,1,1,17,21,
Solute Flux,Sr-90,1/yr.,west,33,33,1,1,17,21,
Solute Flux,Zn-65,1/yr.,west,33,33,1,1,17,21,
Solute Flux,Eu-155,1/yr.,west,33,33,1,1,17,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,41,41,1,1,10,21,
#Solute Flux,H-3,1/yr.,west,41,41,1,1,10,21,
#Solute Flux,I-129,1/yr.,west,41,41,1,1,10,21,
#Solute Flux,Tc-99,1/yr.,west,41,41,1,1,10,21,
#Solute Flux,U-235,1/yr.,west,41,41,1,1,10,21,
Solute Flux,Np-237,1/yr.,west,41,41,1,1,10,21,
Solute Flux,Sr-90,1/yr.,west,41,41,1,1,10,21,
Solute Flux,Zn-65,1/yr.,west,41,41,1,1,10,21,
Solute Flux,Eu-155,1/yr.,west,41,41,1,1,10,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,41,41,1,1,17,21,
#Solute Flux,H-3,1/yr.,west,41,41,1,1,17,21,
#Solute Flux,I-129,1/yr.,west,41,41,1,1,17,21,
#Solute Flux,Tc-99,1/yr.,west,41,41,1,1,17,21,
#Solute Flux,U-235,1/yr.,west,41,41,1,1,17,21,
Solute Flux,Np-237,1/yr.,west,41,41,1,1,17,21,
Solute Flux,Sr-90,1/yr.,west,41,41,1,1,17,21,
Solute Flux,Zn-65,1/yr.,west,41,41,1,1,17,21,
Solute Flux,Eu-155,1/yr.,west,41,41,1,1,17,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,58,58,1,1,10,21,
#Solute Flux,H-3,1/yr.,west,58,58,1,1,10,21,
#Solute Flux,I-129,1/yr.,west,58,58,1,1,10,21,
#Solute Flux,Tc-99,1/yr.,west,58,58,1,1,10,21,
#Solute Flux,U-235,1/yr.,west,58,58,1,1,10,21,
Solute Flux,Np-237,1/yr.,west,58,58,1,1,10,21,
Solute Flux,Sr-90,1/yr.,west,58,58,1,1,10,21,
Solute Flux,Zn-65,1/yr.,west,58,58,1,1,10,21,
Solute Flux,Eu-155,1/yr.,west,58,58,1,1,10,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,58,58,1,1,17,21,
#Solute Flux,H-3,1/yr.,west,58,58,1,1,17,21,
#Solute Flux,I-129,1/yr.,west,58,58,1,1,17,21,
#Solute Flux,Tc-99,1/yr.,west,58,58,1,1,17,21,
#Solute Flux,U-235,1/yr.,west,58,58,1,1,17,21,
Solute Flux,Np-237,1/yr.,west,58,58,1,1,17,21,
Solute Flux,Sr-90,1/yr.,west,58,58,1,1,17,21,
Solute Flux,Zn-65,1/yr.,west,58,58,1,1,17,21,
Solute Flux,Eu-155,1/yr.,west,58,58,1,1,17,21,
#
~Output Control Card
48,
21,1,10,
21,1,11,
21,1,12,
21,1,13,
21,1,14,
21,1,15,

```

21,1,16,
21,1,17,
21,1,18,
21,1,19,
21,1,20,
21,1,21,
33,1,10,
33,1,11,
33,1,12,
33,1,13,
33,1,14,
33,1,15,
33,1,16,
33,1,17,
33,1,18,
33,1,19,
33,1,20,
33,1,21,
41,1,10,
41,1,11,
41,1,12,
41,1,13,
41,1,14,
41,1,15,
41,1,16,
41,1,17,
41,1,18,
41,1,19,
41,1,20,
41,1,21,
58,1,10,
58,1,11,
58,1,12,
58,1,13,
58,1,14,
58,1,15,
58,1,16,
58,1,17,
58,1,18,
58,1,19,
58,1,20,
58,1,21,
1,1,yr,m,8,8,8,
8,
aqueous saturation,,
aqueous pressure,Pa,
aqueous moisture content,,
znc aqueous vol,m/yr,
solute aqueous concentration,Np-237,,
solute aqueous concentration,Sr-90,,
solute aqueous concentration,Zn-65,,
solute aqueous concentration,Eu-155,,
12,
#1,yr,
10,yr,
100,yr,
200,yr,

500,yr,
1000,yr,
1200,yr,
1500,yr,
2000,yr,
#2500,yr,
5000,yr,
10000,yr,
#20000,yr,
50000,yr,
100000,yr,
#200000,yr,
8,
aqueous saturation,,
aqueous pressure,Pa,
aqueous moisture content,,
znc aqueous vol,m/yr,
solute aqueous concentration,Np-237,,
solute aqueous concentration,Sr-90,,
solute aqueous concentration,Zn-65,,
solute aqueous concentration,Eu-155,,
rock/soil type,,

E.4. NATURAL RECHARGE, SURROGATES 9 – 12 INPUT

~Simulation Title Card

1,
B Pond Lengthwise Cross Section,
WJ McMahon,
CH2M Hill Hanford,
July 23 2001,
10:00 AM PDT,
3,

This input file is the contaminant transport run for the INEEL ICDF simulation

This construction uses the geology developed by Pete Martian
The input parameters are based on PM reports

~Solution Control Card

Restart,restart,
Water w/ Solute Transport,
9,
0,day,20,yr,0.0007,yr,0.02,yr,1.25,8,1.e-6,
20,yr,50,yr,0.02,yr,0.05,yr,1.25,8,1.e-6,
50,yr,100,yr,0.05,yr,0.10,yr,1.25,8,1.e-6,
100,yr,500,yr,0.10,yr,0.5,yr,1.25,8,1.e-6,
500,yr,1000,yr,0.5,yr,2,yr,1.25,8,1.e-6,
1000,yr,5000,yr,2,yr,10,yr,1.25,8,1.e-6,
5000,yr,10000,yr,10,yr,100,yr,1.25,8,1.e-6,
10000,yr,100000,yr,100,yr,1000,yr,1.25,8,1.e-6,
100000,yr,1000000,yr,1000,yr,10000,yr,1.25,8,1.e-6,
8000,
0,

~Grid Card

cartesian,
60,1,98,
X Dimensions::160 m ICDF cell Total X Dimension 320 m
0.,m,6@15,m,5@10,m,2@5,m,2@5,m,
#20 m to screening model compliance point,
2@5,m,1@4.,m,1@3.,m,1@2.,m,1@1.,m,
#190 feet (or 58 m) to edge of landfill cap (less 20 m above)
2@2.,m,1@3,m,1@4.,m,2@6.,m,1@4.,m,2@3.,m,2@2,m,1@1.,m,
#190 feet (or 58 m) plus 20 m (less 58 m above)
2@2.,m,1@3,m,1@4.,m,2@3.,m,1@2,m,1@1.,m,
#190 feet (or 58 m) plus 100 m (less 78 m above)
2@2.,m,1@3,m,2@4.,m,2@5.,m,5@8.,m,1@5.,m,1@4.,m,1@3.,m,1@2,m,1@1.,m,
#One grid block to move last observation point off of boundary
2@1.,m,
Y Dimensions (Y dimension not used)
0.,m,1.,m,
Z Dimensions
#Basalt Aquifer (Total = 76 m, Begin and End Lower 61 m) 9 Rows (Ignore 0)
0.,m,2@12.,m,2@8.,m,2@6.,m,1@4.,m,1@3.,m,1@2.,m,
#Basalt Aquifer Begin First 9 m of Upper 15 m 6 Rows
6@1.5,m,
#Basalt Aquifer Begin and End Upper 6 m
(7 m or 22 ft-note 6 m saturated and 1 m above water table) 6 Rows
1@1,m,1@1,m,1@1,m,1@1,m,1@2,m,

```

#Basalt (16.98 m or 57 ft-note that 1 m added to aquifer layer, 17.98 m = 59
ft)
# 7 Rows
1@2,m,1@2.32,m,1@2.75,m,1@3.25,m,1@3,m,1@2.15,m,1@1.51,m,
#Sedimentary Interbed (7.01 m or 23 ft) 4 Rows
1@1.51,m,1@2,m,1@2,m,1@1.5,m,
#Basalt (39.93 m or 131 ft) 13 Rows
1@1.5,m,1@2,m,1@3,m,1@4,m,1@4,m,1@4.5,m,1@4.5,m,1@4,m,1@4,m,1@3,m,1@2.4,m,
1@1.81,m,1@1.22,m,
#Sedimentary Interbed (4.88 m or 16 ft) 4 Rows
1@1.22,m,1@1.22,m,1@1.22,m,1@1.22,m,
#Basalt (23.47 m or 77 ft) 9 Rows
1@1.22,m,1@2,m,1@3,m,1@3.5,m,1@3.75,m,1@3.5,m,1@3,m,1@2,m,1@1.5,m,
#Sedimentary Interbed (11.89 m or 39 ft) 6 Rows
1@1.5,m,1@1.94,m,1@2.45,m,1@2.45,m,1@2.15,m,1@1.4,m,
#Basalt (26.52 m or 87 ft) 13 Rows
1@1.4,m,1@2,m,1@3,m,1@5,m,1@5,m,1@3,m,1@1.57,m,1@1.2,m,1@1,m,1@0.6,m,
1@0.45,m,1@0.3,m,
#Alluvium changed from 9 to 5 feet (1.52 m or 5 ft) 4 Rows
1@0.30,m,1@0.46,m,1@0.46,m,1@0.30,m,
#Clay Liner (0.91 m or 3 ft) 3 Rows
1@0.30,m,1@0.31,m,1@0.30,m,
#Operations Layer (0.91 m or 3 ft) 3 Rows
1@0.30,m,1@0.31,m,1@0.30,m,
#Waste (10.40 m or 34 ft adjusted to 12.56 m to account for cube vs
trapezoid)
# 11 Rows
1@0.5,m,1@0.5,m,1@1,m,1@1,m,1@1.64,m,1@1.64,m,1@1.64,m,1@1.64,m,1@1,m,1
@1,m,

```

~Rock/Soil Zonation Card

```

14,
#Lower 61 m of Basalt Aquifer
Basalt Aquifer,1,60,1,1,1,9,
#Begin First 9 m of Upper 15 m of Basalt Aquifer
Basalt Aquifer,1,60,1,1,10,15,
#Upper 6 m of Basalt Aquifer
Basalt Aquifer,1,60,1,1,16,21,
#Lowest Vadose Basalt Layer
Basalt,1,60,1,1,22,28,
Interbed,1,60,1,1,29,32,
Basalt,1,60,1,1,33,45,
Interbed,1,60,1,1,46,49,
Basalt,1,60,1,1,50,58,
Interbed,1,60,1,1,59,64,
Basalt,1,60,1,1,65,77,
Alluvium,1,60,1,1,78,81,
Clay,1,60,1,1,82,84,
Operation Gravelly Sand,1,60,1,1,85,87,
Waste Gravelly Sand,1,60,1,1,88,98,

```

~Inactive Nodes Card

```

#Integer,
1,
16,60,1,1,22,98,

```

~Mechanical Properties Card

```

#Particle density = 2650 kg/m^3 except for clay and old alluvium
#Subgrade, attenuation barrier, and drain rock used in earlier models but
#not used here
#Basalt and interbed properties from P. Martian Screening Model
Basalt Aquifer,,,0.06,0.06,,,Millington and Quirk,
Interbed,,,0.487,0.487,,,Millington and Quirk,
Basalt,,,0.05,0.05,,,Millington and Quirk,
#
#Old Alluvium characteristics from Geotech report measurements
# sat. moisture content (0.422, 0.426); dry bulk density (1.60, 1.64 g/cm^3)
# particle density = 1.62 g/cm^3/(1-0.424) = 2.8125 g/cm^3
Alluvium,2812.5,kg/m^3,0.424,0.424,,,Millington and Quirk,
#Attenuation Barrier,,,0.400,0.400,,,Millington and Quirk,
#Clay characteristics per discussion with J. Dehner
Clay,2600,kg/m^3,0.390,0.390,,,Millington and Quirk,
#Drain Rock,,,0.400,0.400,,,Millington and Quirk,
Operation Gravelly Sand,,,0.275,0.275,,,Millington and Quirk,
#Operation Gravelly Sand dry bulk density = 120 lb/ft^3 (per J. Dehner)
#120 lb/ft^3*0.4536 kg/lb*1 ft^3/(0.3048 m/ft)^3 = 1922.25 kg/m^3
#Porosity Operation Gravelly Sand = 1-(1922.25/2650)= 0.275
Waste Gravelly Sand,,,0.266,0.266,,,Millington and Quirk,
#Waste Gravelly Sand dry bulk density = 121.5 lb/ft^3 (per J. Dehner)
#121.5 lb/ft^3*0.4536 kg/lb*1 ft^3/(0.3048 m)^3 = 1946.28 kg/m^3
#Porosity Waste Gravelly Sand = 1-(1946.28/2650)= 0.266

```

-Hydraulic Properties Card

```

#Properties from P. Martian Screening Model except old alluvium
Basalt Aquifer,9.00e+01,darcy,,,3.00e-01,darcy,
Interbed,6.7e-5,hc:cm/s,,,6.7e-5,hc:cm/s,
Basalt,9.00e+01,darcy,,,3.00e-01,darcy,
#Old Alluvium characteristics from Geotech report measurements
# sat. hydraulic conductivity (1.2e-07 cm/s, 6.2e-08 cm/s, 7.1e-08 cm/s)
Alluvium,1.2e-07,hc:cm/s,,,1.2e-07,hc:cm/s,
#Subgrade,1e-04,hc:cm/s,,,1e-04,hc:cm/s,
#Attenuation Barrier,1e-07,hc:cm/s,,,1e-07,hc:cm/s,
Clay,1e-07,hc:cm/s,,,1e-07,hc:cm/s,
#Drain Rock,3.0e-01,hc:cm/s,,,3.0e-01,hc:cm/s,
Operation Gravelly Sand,1e-04,hc:cm/s,,,1e-04,hc:cm/s,
Waste Gravelly Sand,1e-03,hc:cm/s,,,1e-03,hc:cm/s,

```

-Saturation Function Card

```

#Parameters from P. Martian Screening Model except old alluvium
#alpha, n, theta R, m
#m only specified for basalts, otherwise default m = 1 - 1/n
Basalt Aquifer,Nonhysteretic van Genuchten,4.0,1/m,4.5,0.0002,0.7777778,
Interbed,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.142.,
Basalt,Nonhysteretic van Genuchten,4.0,1/m,4.5,0.0002,0.7777778,
#Old Alluvium characteristics from RETC fitting of Geotech report
measurements
Alluvium,Nonhysteretic van Genuchten,0.595,1/m,1.09,0.142.,
#Subgrade,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.142.,
#Attenuation Barrier,Nonhysteretic van Genuchten,0.800,1/m,1.090,0.07.,
Clay,Nonhysteretic van Genuchten,0.800,1/m,1.109,0.07.,
#Drain Rock,Nonhysteretic van Genuchten,493,1/m,2.190,0.005.,
Operation Gravelly Sand,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.083.,
Waste Gravelly Sand,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.072.,
#

```

```

~Aqueous Relative Permeability Card
#m only specified for basalts, otherwise default m = 1 - 1/n
Basalt Aquifer,Mualem,1.9,
Interbed,Mualem.,
Basalt,Mualem,1.9,
Alluvium,Mualem.,
#Subgrade,Mualem.,
#Attenuation Barrier,Mualem.,
Clay,Mualem.,
#Drain Rock,Mualem.,
Operation Gravelly Sand,Mualem.,
Waste Gravelly Sand,Mualem.,
#
~Solute/Fluid Interactions Card
4,
#H-3,conventional,1.0e-09,m^2/s,noncontinuous...
I-129A,conventional,1.0e-09,m^2/s,noncontinuous...
I-129B,conventional,1.0e-09,m^2/s,noncontinuous...
#U-235,conventional,1.0e-09,m^2/s,noncontinuous...
#Np-237,conventional,1.0e-09,m^2/s,noncontinuous...
Sr-90,conventional,1.0e-09,m^2/s,noncontinuous...
#Zn-65,conventional,1.0e-09,m^2/s,noncontinuous...
Eu-155,conventional,1.0e-09,m^2/s,noncontinuous...
0,
#
~Solute/Porous Media Interaction Card
Basalt Aquifer,6.0,m,3.0,m,
#H-3,0.0,cm^3/g,
I-129A,0.0,cm^3/g,
I-129B,0.0,cm^3/g,
#U-235,0.24,cm^3/g,
#Np-237,0.32,cm^3/g,
Sr-90,0.48,cm^3/g,
#Zn-65,0.64,cm^3/g,
Eu-155,13.6,cm^3/g,
#
Interbed,5.0,m,0,m,
#H-3,0.0,cm^3/g,
I-129A,0.0,cm^3/g,
I-129B,0.1,cm^3/g,
#U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
Sr-90,12.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
Basalt,5.0,m,0,m,
#H-3,0.0,cm^3/g,
I-129A,0.0,cm^3/g,
I-129B,0.0,cm^3/g,
#U-235,0.0,cm^3/g,
#Np-237,0.0,cm^3/g,
Sr-90,0.0,cm^3/g,
#Zn-65,0.0,cm^3/g,
Eu-155,0,cm^3/g,
#
#Subgrade,5.0,m,0,m,

```

```

#
Alluvium,5.0,m,0,m,
#H-3,0.0,cm^3/g,
I-129A,0.0,cm^3/g,
I-129B,0.1,cm^3/g,
#U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
Sr-90,24.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
#Attenuation Barrier,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129A,1.0,cm^3/g,
#I-129B,1.0,cm^3/g,
#U-235,63.0,cm^3/g,
#Np-237,55.0,cm^3/g,
#Sr-90,200.0,cm^3/g,
#Zn-65,2400.0,cm^3/g,
#Eu-155,340,cm^3/g,
#
Clay,5.0,m,0,m,
#H-3,0.0,cm^3/g,
I-129A,1.0,cm^3/g,
I-129B,1.0,cm^3/g,
#U-235,63.0,cm^3/g,
#Np-237,55.0,cm^3/g,
Sr-90,200.0,cm^3/g,
#Zn-65,2400.0,cm^3/g,
Eu-155,340,cm^3/g,
#
#Drain Rock,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129A,0.0,cm^3/g,
#I-129B,0.1,cm^3/g,
#U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
#Sr-90,24.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
#Eu-155,340,cm^3/g,
#
Operation Gravelly Sand,5.0,m,0,m,
#H-3,0.0,cm^3/g,
I-129A,0.0,cm^3/g,
I-129B,0.1,cm^3/g,
#U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
Sr-90,12.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
Waste Gravelly Sand,5.0,m,0,m,
#H-3,0.0,cm^3/g,
I-129A,0.1,cm^3/g,
I-129B,0.1,cm^3/g,
#U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,

```

```

Sr-90,12.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
~Initial Conditions Card
Gas Pressure,Aqueous Pressure,
9,
Aqueous Pressure,,.,.,1,60,1,1,1,98,
#Solute Volume Overwrite,H-3,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,I-129A,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,I-129B,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,U-235,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,Np-237,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Sr-90,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,Zn-65,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Eu-155,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#
#Solute Volume Overwrite,H-3,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,I-129A,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,I-129B,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,U-235,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,Np-237,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Sr-90,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,Zn-65,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Eu-155,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,

~Boundary Conditions Card
4,
#
top,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#0.01 m/yr * 1.74 ICDF Recharge Ratio = 0.0174 m/yr
1,15,1,1,98,98,1,
0,day,-0.0174,m/yr,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
west,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
1,1,1,1,1,20,1,
0,day,0.06,m/day,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
west,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
1,1,1,1,21,21,1,
0,day,0.03,m/day,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
east,hydraulic gradient,outflow,outflow,outflow,outflow,
#Hold head constant to keep h ~ 5 m at compliance point
60,60,1,1,1,21,1,

```

```

0,day,786871.34,Pa,,,,,,,,,,,
#
~Surface Flux Card
50,
Aqueous Volumetric Flux,m^3/yr,m^3,bottom,1,15,1,1,82,82,
#Solute Flux,H-3,1/yr,,bottom,1,15,1,1,82,82,
Solute Flux,I-129A,1/yr,,bottom,1,15,1,1,82,82,
Solute Flux,I-129B,1/yr,,bottom,1,15,1,1,82,82,
#Solute Flux,U-235,1/yr,,bottom,1,15,1,1,82,82,
#Solute Flux,Np-237,1/yr,,bottom,1,15,1,1,82,82,
Solute Flux,Sr-90,1/yr,,bottom,1,15,1,1,82,82,
#Solute Flux,Zn-65,1/yr,,bottom,1,15,1,1,82,82,
Solute Flux,Eu-155,1/yr,,bottom,1,15,1,1,82,82,
#
Aqueous Volumetric Flux,m^3/yr,m^3,bottom,1,15,1,1,22,22,
#Solute Flux,H-3,1/yr,,bottom,1,15,1,1,22,22,
Solute Flux,I-129A,1/yr,,bottom,1,15,1,1,22,22,
Solute Flux,I-129B,1/yr,,bottom,1,15,1,1,22,22,
#Solute Flux,U-235,1/yr,,bottom,1,15,1,1,22,22,
#Solute Flux,Np-237,1/yr,,bottom,1,15,1,1,22,22,
Solute Flux,Sr-90,1/yr,,bottom,1,15,1,1,22,22,
#Solute Flux,Zn-65,1/yr,,bottom,1,15,1,1,22,22,
Solute Flux,Eu-155,1/yr,,bottom,1,15,1,1,22,22,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,21,21,1,1,10,21,
#Solute Flux,H-3,1/yr,,west,21,21,1,1,10,21,
Solute Flux,I-129A,1/yr,,west,21,21,1,1,10,21,
Solute Flux,I-129B,1/yr,,west,21,21,1,1,10,21,
#Solute Flux,U-235,1/yr,,west,21,21,1,1,10,21,
#Solute Flux,Np-237,1/yr,,west,21,21,1,1,10,21,
Solute Flux,Sr-90,1/yr,,west,21,21,1,1,10,21,
#Solute Flux,Zn-65,1/yr,,west,21,21,1,1,10,21,
Solute Flux,Eu-155,1/yr,,west,21,21,1,1,10,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,21,21,1,1,17,21,
#Solute Flux,H-3,1/yr,,west,21,21,1,1,17,21,
Solute Flux,I-129A,1/yr,,west,21,21,1,1,17,21,
Solute Flux,I-129B,1/yr,,west,21,21,1,1,17,21,
#Solute Flux,U-235,1/yr,,west,21,21,1,1,17,21,
#Solute Flux,Np-237,1/yr,,west,21,21,1,1,17,21,
Solute Flux,Sr-90,1/yr,,west,21,21,1,1,17,21,
#Solute Flux,Zn-65,1/yr,,west,21,21,1,1,17,21,
Solute Flux,Eu-155,1/yr,,west,21,21,1,1,17,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,33,33,1,1,10,21,
#Solute Flux,H-3,1/yr,,west,33,33,1,1,10,21,
Solute Flux,I-129A,1/yr,,west,33,33,1,1,10,21,
Solute Flux,I-129B,1/yr,,west,33,33,1,1,10,21,
#Solute Flux,U-235,1/yr,,west,33,33,1,1,10,21,
#Solute Flux,Np-237,1/yr,,west,33,33,1,1,10,21,
Solute Flux,Sr-90,1/yr,,west,33,33,1,1,10,21,
#Solute Flux,Zn-65,1/yr,,west,33,33,1,1,10,21,
Solute Flux,Eu-155,1/yr,,west,33,33,1,1,10,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,33,33,1,1,17,21,
#Solute Flux,H-3,1/yr,,west,33,33,1,1,17,21,
Solute Flux,I-129A,1/yr,,west,33,33,1,1,17,21,

```

```

Solute Flux,I-129B,1/yr.,west,33,33,1,1,17,21,
#Solute Flux,U-235,1/yr.,west,33,33,1,1,17,21,
#Solute Flux,Np-237,1/yr.,west,33,33,1,1,17,21,
Solute Flux,Sr-90,1/yr.,west,33,33,1,1,17,21,
#Solute Flux,Zn-65,1/yr.,west,33,33,1,1,17,21,
Solute Flux,Eu-155,1/yr.,west,33,33,1,1,17,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,41,41,1,1,10,21,
#Solute Flux,H-3,1/yr.,west,41,41,1,1,10,21,
Solute Flux,I-129A,1/yr.,west,41,41,1,1,10,21,
Solute Flux,I-129B,1/yr.,west,41,41,1,1,10,21,
#Solute Flux,U-235,1/yr.,west,41,41,1,1,10,21,
#Solute Flux,Np-237,1/yr.,west,41,41,1,1,10,21,
Solute Flux,Sr-90,1/yr.,west,41,41,1,1,10,21,
#Solute Flux,Zn-65,1/yr.,west,41,41,1,1,10,21,
Solute Flux,Eu-155,1/yr.,west,41,41,1,1,10,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,41,41,1,1,17,21,
#Solute Flux,H-3,1/yr.,west,41,41,1,1,17,21,
Solute Flux,I-129A,1/yr.,west,41,41,1,1,17,21,
Solute Flux,I-129B,1/yr.,west,41,41,1,1,17,21,
#Solute Flux,U-235,1/yr.,west,41,41,1,1,17,21,
#Solute Flux,Np-237,1/yr.,west,41,41,1,1,17,21,
Solute Flux,Sr-90,1/yr.,west,41,41,1,1,17,21,
#Solute Flux,Zn-65,1/yr.,west,41,41,1,1,17,21,
Solute Flux,Eu-155,1/yr.,west,41,41,1,1,17,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,58,58,1,1,10,21,
#Solute Flux,H-3,1/yr.,west,58,58,1,1,10,21,
Solute Flux,I-129A,1/yr.,west,58,58,1,1,10,21,
Solute Flux,I-129B,1/yr.,west,58,58,1,1,10,21,
#Solute Flux,U-235,1/yr.,west,58,58,1,1,10,21,
#Solute Flux,Np-237,1/yr.,west,58,58,1,1,10,21,
Solute Flux,Sr-90,1/yr.,west,58,58,1,1,10,21,
#Solute Flux,Zn-65,1/yr.,west,58,58,1,1,10,21,
Solute Flux,Eu-155,1/yr.,west,58,58,1,1,10,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,58,58,1,1,17,21,
#Solute Flux,H-3,1/yr.,west,58,58,1,1,17,21,
Solute Flux,I-129A,1/yr.,west,58,58,1,1,17,21,
Solute Flux,I-129B,1/yr.,west,58,58,1,1,17,21,
#Solute Flux,U-235,1/yr.,west,58,58,1,1,17,21,
#Solute Flux,Np-237,1/yr.,west,58,58,1,1,17,21,
Solute Flux,Sr-90,1/yr.,west,58,58,1,1,17,21,
#Solute Flux,Zn-65,1/yr.,west,58,58,1,1,17,21,
Solute Flux,Eu-155,1/yr.,west,58,58,1,1,17,21,
#
~Output Control Card
48,
21,1,10,
21,1,11,
21,1,12,
21,1,13,
21,1,14,
21,1,15,
21,1,16,
21,1,17,

```

21,1,18,
21,1,19,
21,1,20,
21,1,21,
33,1,10,
33,1,11,
33,1,12,
33,1,13,
33,1,14,
33,1,15,
33,1,16,
33,1,17,
33,1,18,
33,1,19,
33,1,20,
33,1,21,
41,1,10,
41,1,11,
41,1,12,
41,1,13,
41,1,14,
41,1,15,
41,1,16,
41,1,17,
41,1,18,
41,1,19,
41,1,20,
41,1,21,
58,1,10,
58,1,11,
58,1,12,
58,1,13,
58,1,14,
58,1,15,
58,1,16,
58,1,17,
58,1,18,
58,1,19,
58,1,20,
58,1,21,
1,1,yr,m,8,8,8,
8,
aqueous saturation,,
aqueous pressure,Pa,
aqueous moisture content,,
znc aqueous vol,m/yr,
solute aqueous concentration,I-129A,,
solute aqueous concentration,I-129B,,
solute aqueous concentration,Sr-90,,
solute aqueous concentration,Eu-155,,
12,
#1,yr,
10,yr,
100,yr,
200,yr,
500,yr,
1000,yr,

1200, yr,
1500, yr,
2000, yr,
#2500, yr,
5000, yr,
10000, yr,
#20000, yr,
50000, yr,
100000, yr,
#200000, yr,
8,
aqueous saturation,,
aqueous pressure, Pa,
aqueous moisture content,,
znc aqueous vol, m/yr,
solute aqueous concentration, I-129A,,
solute aqueous concentration, I-129B,,
solute aqueous concentration, Sr-90,,
solute aqueous concentration, Eu-155,,
rock/soil type,,

E.5. DESIGN RECHARGE, SURROGATES 1 – 4 INPUT, PART A

~Simulation Title Card

1,
B Pond Lengthwise Cross Section,
WJ McMahon,
CH2M Hill Hanford,
July 23 2001,
10:00 AM PDT,
3,

This input file is the contaminant transport run for the INEEL ICDF simulation

This construction uses the geology developed by Pete Martian
The input parameters are based on PM reports

~Solution Control Card

Restart,restart,
Water w/ Solute Transport,
9,

0,day,20,yr,0.0007,yr,0.02,yr,1.25,8,1.e-6,
20,yr,50,yr,0.02,yr,0.05,yr,1.25,8,1.e-6,
50,yr,100,yr,0.05,yr,0.10,yr,1.25,8,1.e-6,
100,yr,500,yr,0.10,yr,0.50,yr,1.25,8,1.e-6,
500,yr,1000,yr,0.50,yr,2,yr,1.25,8,1.e-6,
1000,yr,5000,yr,2,yr,10,yr,1.25,8,1.e-6,
5000,yr,10000,yr,10,yr,100,yr,1.25,8,1.e-6,
10000,yr,100000,yr,100,yr,1000,yr,1.25,8,1.e-6,
100000,yr,1000000,yr,1000,yr,10000,yr,1.25,8,1.e-6,
8000,
0,

~Grid Card

cartesian,
60,1,98,
X Dimensions::160 m ICDF cell Total X Dimension 320 m
0.,m,6@15,m,5@10,m,2@5,m,2@5,m,
#20 m to screening model compliance point,
2@5,m,1@4.,m,1@3.,m,1@2.,m,1@1.,m,
#190 feet (or 58 m) to edge of landfill cap (less 20 m above)
2@2.,m,1@3,m,1@4.,m,2@6.,m,1@4.,m,2@3.,m,2@2,m,1@1.,m,
#190 feet (or 58 m) plus 20 m (less 58 m above)
2@2.,m,1@3,m,1@4.,m,2@3.,m,1@2,m,1@1.,m,
#190 feet (or 58 m) plus 100 m (less 78 m above)
2@2.,m,1@3,m,2@4.,m,2@5.,m,5@8.,m,1@5.,m,1@4.,m,1@3.,m,1@2,m,1@1.,m,
#One grid block to move last observation point off of boundary
2@1.,m,
Y Dimensions (Y dimension not used)
0.,m,1.,m,
Z Dimensions
#Basalt Aquifer (Total = 76 m, Begin and End Lower 61 m) 9 Rows (Ignore 0)
0.,m,2@12.,m,2@8.,m,2@6.,m,1@4.,m,1@3.,m,1@2.,m,
#Basalt Aquifer Begin First 9 m of Upper 15 m 6 Rows
6@1.5,m,
#Basalt Aquifer Begin and End Upper 6 m
(7 m or 22 ft-note 6 m saturated and 1 m above water table) 6 Rows
1@1,m,1@1,m,1@1,m,1@1,m,1@2,m,

```

#Basalt (16.98 m or 57 ft-note that 1 m added to aquifer layer, 17.98 m = 59
ft)
# 7 Rows
1@2,m,1@2.32,m,1@2.75,m,1@3.25,m,1@3,m,1@2.15,m,1@1.51,m,
#Sedimentary Interbed (7.01 m or 23 ft) 4 Rows
1@1.51,m,1@2,m,1@2,m,1@1.5,m,
#Basalt (39.93 m or 131 ft) 13 Rows
1@1.5,m,1@2,m,1@3,m,1@4,m,1@4,m,1@4.5,m,1@4.5,m,1@4,m,1@4,m,1@3,m,1@2.4,m,
1@1.81,m,1@1.22,m,
#Sedimentary Interbed (4.88 m or 16 ft) 4 Rows
1@1.22,m,1@1.22,m,1@1.22,m,1@1.22,m,
#Basalt (23.47 m or 77 ft) 9 Rows
1@1.22,m,1@2,m,1@3,m,1@3.5,m,1@3.75,m,1@3.5,m,1@3,m,1@2,m,1@1.5,m,
#Sedimentary Interbed (11.89 m or 39 ft) 6 Rows
1@1.5,m,1@1.94,m,1@2.45,m,1@2.45,m,1@2.15,m,1@1.4,m,
#Basalt (26.52 m or 87 ft) 13 Rows
1@1.4,m,1@2,m,1@2,m,1@3,m,1@5,m,1@5,m,1@3,m,1@1.57,m,1@1.2,m,1@1,m,1@0.6,m,
1@0.45,m,1@0.3,m,
#Alluvium changed from 9 to 5 feet (1.52 m or 5 ft) 4 Rows
1@0.30,m,1@0.46,m,1@0.46,m,1@0.30,m,
#Clay Liner (0.91 m or 3 ft) 3 Rows
1@0.30,m,1@0.31,m,1@0.30,m,
#Operations Layer (0.91 m or 3 ft) 3 Rows
1@0.30,m,1@0.31,m,1@0.30,m,
#Waste (10.40 m or 34 ft adjusted to 12.56 m to account for cube vs
trapezoid)
# 11 Rows
1@0.5,m,1@0.5,m,1@1,m,1@1,m,1@1.64,m,1@1.64,m,1@1.64,m,1@1.64,m,1@1,m,1
@1,m,

```

~Rock/Soil Zonation Card

```

14,
#Lower 61 m of Basalt Aquifer
Basalt Aquifer,1,60,1,1,1,9,
#Begin First 9 m of Upper 15 m of Basalt Aquifer
Basalt Aquifer,1,60,1,1,10,15,
#Upper 6 m of Basalt Aquifer
Basalt Aquifer,1,60,1,1,16,21,
#Lowest Vadose Basalt Layer
Basalt,1,60,1,1,22,28,
Interbed,1,60,1,1,29,32,
Basalt,1,60,1,1,33,45,
Interbed,1,60,1,1,46,49,
Basalt,1,60,1,1,50,58,
Interbed,1,60,1,1,59,64,
Basalt,1,60,1,1,65,77,
Alluvium,1,60,1,1,78,81,
Clay,1,60,1,1,82,84,
Operation Gravelly Sand,1,60,1,1,85,87,
Waste Gravelly Sand,1,60,1,1,88,98,

```

~Inactive Nodes Card

```

#Integer,
1,
16,60,1,1,22,98,

```

~Mechanical Properties Card

```

#Particle density = 2650 kg/m^3 except for clay and old alluvium
#Subgrade, attenuation barrier, and drain rock used in earlier models but
#not used here
#Basalt and interbed properties from P. Martian Screening Model
Basalt Aquifer,,,0.06,0.06,,,Millington and Quirk,
Interbed,,,0.487,0.487,,,Millington and Quirk,
Basalt,,,0.05,0.05,,,Millington and Quirk,
#
#Old Alluvium characteristics from Geotech report measurements
# sat. moisture content (0.422, 0.426); dry bulk density (1.60, 1.64 g/cm^3)
# particle density = 1.62 g/cm^3/(1-0.424) = 2.8125 g/cm^3
Alluvium,2812.5,kg/m^3,0.424,0.424,,,Millington and Quirk,
#Attenuation Barrier,,,0.400,0.400,,,Millington and Quirk,
#Clay characteristics per discussion with J. Dehner
Clay,2600,kg/m^3,0.390,0.390,,,Millington and Quirk,
#Drain Rock,,,0.400,0.400,,,Millington and Quirk,
Operation Gravelly Sand,,,0.275,0.275,,,Millington and Quirk,
#Operation Gravelly Sand dry bulk density = 120 lb/ft^3 (per J. Dehner)
#120 lb/ft^3*0.4536 kg/lb*1 ft^3/(0.3048 m/ft)^3 = 1922.25 kg/m^3
#Porosity Operation Gravelly Sand = 1-(1922.25/2650)= 0.275
Waste Gravelly Sand,,,0.266,0.266,,,Millington and Quirk,
#Waste Gravelly Sand dry bulk density = 121.5 lb/ft^3 (per J. Dehner)
#121.5 lb/ft^3*0.4536 kg/lb*1 ft^3/(0.3048 m)^3 = 1946.28 kg/m^3
#Porosity Waste Gravelly Sand = 1-(1946.28/2650)= 0.266

```

-Hydraulic Properties Card

```

#Properties from P. Martian Screening Model except old alluvium
Basalt Aquifer,9.00e+01,darcy,,,3.00e-01,darcy,
Interbed,6.7e-5,hc:cm/s,,,6.7e-5,hc:cm/s,
Basalt,9.00e+01,darcy,,,3.00e-01,darcy,
#Old Alluvium characteristics from Geotech report measurements
# sat. hydraulic conductivity (1.2e-07 cm/s, 6.2e-08 cm/s, 7.1e-08 cm/s)
Alluvium,1.2e-07,hc:cm/s,,,1.2e-07,hc:cm/s,
#Subgrade,1e-04,hc:cm/s,,,1e-04,hc:cm/s,
#Attenuation Barrier,1e-07,hc:cm/s,,,1e-07,hc:cm/s,
Clay,1e-07,hc:cm/s,,,1e-07,hc:cm/s,
#Drain Rock,3.0e-01,hc:cm/s,,,3.0e-01,hc:cm/s,
Operation Gravelly Sand,1e-04,hc:cm/s,,,1e-04,hc:cm/s,
Waste Gravelly Sand,1e-03,hc:cm/s,,,1e-03,hc:cm/s,

```

-Saturation Function Card

```

#Parameters from P. Martian Screening Model except old alluvium
#alpha, n, theta R, m
#m only specified for basalts, otherwise default m = 1 - 1/n
Basalt Aquifer,Nonhysteretic van Genuchten,4.0,1/m,4.5,0.0002,0.7777778,
Interbed,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.142.,
Basalt,Nonhysteretic van Genuchten,4.0,1/m,4.5,0.0002,0.7777778,
#Old Alluvium characteristics from RETC fitting of Geotech report
measurements
Alluvium,Nonhysteretic van Genuchten,0.595,1/m,1.09,0.142.,
#Subgrade,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.142.,
#Attenuation Barrier,Nonhysteretic van Genuchten,0.800,1/m,1.090,0.07.,
Clay,Nonhysteretic van Genuchten,0.800,1/m,1.109,0.07.,
#Drain Rock,Nonhysteretic van Genuchten,493,1/m,2.190,0.005.,
Operation Gravelly Sand,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.083.,
Waste Gravelly Sand,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.072.,
#

```

```

~Aqueous Relative Permeability Card
#m only specified for basalts, otherwise default m = 1 - 1/n
Basalt Aquifer,Mualem,1.9,
Interbed,Mualem.,
Basalt,Mualem,1.9,
Alluvium,Mualem.,
#Subgrade,Mualem.,
#Attenuation Barrier,Mualem.,
Clay,Mualem.,
#Drain Rock,Mualem.,
Operation Gravelly Sand,Mualem.,
Waste Gravelly Sand,Mualem.,
#
~Solute/Fluid Interactions Card
4,
H-3,conventional,1.0e-09,m^2/s,noncontinuous,,
I-129,conventional,1.0e-09,m^2/s,noncontinuous,,
Tc-99,conventional,1.0e-09,m^2/s,noncontinuous,,
U-235,conventional,1.0e-09,m^2/s,noncontinuous,,
#Np-237,conventional,1.0e-09,m^2/s,noncontinuous,,
#Sr-90,conventional,1.0e-09,m^2/s,noncontinuous,,
#Zn-65,conventional,1.0e-09,m^2/s,noncontinuous,,
#Eu-155,conventional,1.0e-09,m^2/s,noncontinuous,,
0,
#
~Solute/Porous Media Interaction Card
Basalt Aquifer,6.0,m,3.0,m,
H-3,0.0,cm^3/g,
I-129,0.0,cm^3/g,
Tc-99,0.008,cm^3/g,
U-235,0.24,cm^3/g,
#Np-237,0.32,cm^3/g,
#Sr-90,0.48,cm^3/g,
#Zn-65,0.64,cm^3/g,
#Eu-155,314,cm^3/g,
#
Interbed,5.0,m,0,m,
H-3,0.0,cm^3/g,
I-129,0.0,cm^3/g,
Tc-99,0.2,cm^3/g,
U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
#Sr-90,24.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
#Eu-155,314,cm^3/g,
#
Basalt,5.0,m,0,m,
H-3,0.0,cm^3/g,
I-129,0.0,cm^3/g,
Tc-99,0.0,cm^3/g,
U-235,0.0,cm^3/g,
#Np-237,0.0,cm^3/g,
#Sr-90,0.0,cm^3/g,
#Zn-65,0.0,cm^3/g,
#Eu-155,314,cm^3/g,
#
#Subgrade,5.0,m,0,m,

```


Alluvium, 5.0, m, 0, m,
H-3, 0.0, cm^3/g,
I-129, 0.0, cm^3/g,
Tc-99, 0.2, cm^3/g,
U-235, 6.0, cm^3/g,
#Np-237, 8.0, cm^3/g,
#Sr-90, 24.0, cm^3/g,
#Zn-65, 16.0, cm^3/g,
#Eu-155, 314, cm^3/g,

#Attenuation Barrier, 5.0, m, 0, m,
#H-3, 0.0, cm^3/g,
#I-129, 1.0, cm^3/g,
#Tc-99, 1.0, cm^3/g,
#U-235, 63.0, cm^3/g,
#Np-237, 55.0, cm^3/g,
#Sr-90, 200.0, cm^3/g,
#Zn-65, 2400.0, cm^3/g,
#Eu-155, 314, cm^3/g,

Clay, 5.0, m, 0, m,
H-3, 0.0, cm^3/g,
I-129, 1.0, cm^3/g,
Tc-99, 1.0, cm^3/g,
U-235, 63.0, cm^3/g,
#Np-237, 55.0, cm^3/g,
#Sr-90, 200.0, cm^3/g,
#Zn-65, 2400.0, cm^3/g,
#Eu-155, 314, cm^3/g,

#Drain Rock, 5.0, m, 0, m,
#H-3, 0.0, cm^3/g,
#I-129, 0.0, cm^3/g,
#Tc-99, 0.2, cm^3/g,
#U-235, 6.0, cm^3/g,
#Np-237, 8.0, cm^3/g,
#Sr-90, 24.0, cm^3/g,
#Zn-65, 16.0, cm^3/g,
#Eu-155, 314, cm^3/g,

Operation Gravelly Sand, 5.0, m, 0, m,
H-3, 0.0, cm^3/g,
I-129, 0.0, cm^3/g,
Tc-99, 0.2, cm^3/g,
U-235, 6.0, cm^3/g,
#Np-237, 8.0, cm^3/g,
#Sr-90, 24.0, cm^3/g,
#Zn-65, 16.0, cm^3/g,
#Eu-155, 314, cm^3/g,

Waste Gravelly Sand, 5.0, m, 0, m,
H-3, 0.0, cm^3/g,
I-129, 0.0, cm^3/g,
Tc-99, 0.2, cm^3/g,
U-235, 6.0, cm^3/g,
#Np-237, 8.0, cm^3/g,

```

#Sr-90,12.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
#Eu-155,314,cm^3/g,
#
~Initial Conditions Card
Gas Pressure,Aqueous Pressure,
9,
Aqueous Pressure,,.,.,.,1,60,1,1,1,98,
Solute Volume Overwrite,H-3,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,I-129,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Tc-99,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,U-235,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,Np-237,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,Sr-90,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,Zn-65,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,Eu-155,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#
Solute Volume Overwrite,H-3,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,I-129,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Tc-99,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,U-235,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,Np-237,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,Sr-90,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,Zn-65,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,Eu-155,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
#
~Boundary Conditions Card
4,
#
top,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#0.0001 m/yr * 1.74 ICDF Recharge Ratio = 0.000174 m/yr
1,15,1,1,98,98,1,
0,day,-0.000174,m/yr,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
west,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
1,1,1,1,1,20,1,
0,day,0.06,m/day,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
west,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
1,1,1,1,21,1,
0,day,0.03,m/day,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
east,hydraulic gradient,outflow,outflow,outflow,outflow,
#Hold head constant to keep h ~ 5 m at compliance point
60,60,1,1,1,21,1,

```

```

0,day,786871.34,Pa,.....  

#  

~Surface Flux Card  

50,  

Aqueous Volumetric Flux,m^3/yr,m^3,bottom,1,15,1,1,82,82,  

Solute Flux,H-3,1/yr,,bottom,1,15,1,1,82,82,  

Solute Flux,I-129,1/yr,,bottom,1,15,1,1,82,82,  

Solute Flux,Tc-99,1/yr,,bottom,1,15,1,1,82,82,  

Solute Flux,U-235,1/yr,,bottom,1,15,1,1,82,82,  

#Solute Flux,Np-237,1/yr,,bottom,1,15,1,1,82,82,  

#Solute Flux,Sr-90,1/yr,,bottom,1,15,1,1,82,82,  

#Solute Flux,Zn-65,1/yr,,bottom,1,15,1,1,82,82,  

#Solute Flux,Eu-155,1/yr,,bottom,1,15,1,1,82,82,  

#  

Aqueous Volumetric Flux,m^3/yr,m^3,bottom,1,15,1,1,22,22,  

Solute Flux,H-3,1/yr,,bottom,1,15,1,1,22,22,  

Solute Flux,I-129,1/yr,,bottom,1,15,1,1,22,22,  

Solute Flux,Tc-99,1/yr,,bottom,1,15,1,1,22,22,  

Solute Flux,U-235,1/yr,,bottom,1,15,1,1,22,22,  

#Solute Flux,Np-237,1/yr,,bottom,1,15,1,1,22,22,  

#Solute Flux,Sr-90,1/yr,,bottom,1,15,1,1,22,22,  

#Solute Flux,Zn-65,1/yr,,bottom,1,15,1,1,22,22,  

#Solute Flux,Eu-155,1/yr,,bottom,1,15,1,1,22,22,  

#  

Aqueous Volumetric Flux,m^3/yr,m^3,west,21,21,1,1,10,21,  

Solute Flux,H-3,1/yr,,west,21,21,1,1,10,21,  

Solute Flux,I-129,1/yr,,west,21,21,1,1,10,21,  

Solute Flux,Tc-99,1/yr,,west,21,21,1,1,10,21,  

Solute Flux,U-235,1/yr,,west,21,21,1,1,10,21,  

#Solute Flux,Np-237,1/yr,,west,21,21,1,1,10,21,  

#Solute Flux,Sr-90,1/yr,,west,21,21,1,1,10,21,  

#Solute Flux,Zn-65,1/yr,,west,21,21,1,1,10,21,  

#Solute Flux,Eu-155,1/yr,,west,21,21,1,1,10,21,  

#  

Aqueous Volumetric Flux,m^3/yr,m^3,west,21,21,1,1,17,21,  

Solute Flux,H-3,1/yr,,west,21,21,1,1,17,21,  

Solute Flux,I-129,1/yr,,west,21,21,1,1,17,21,  

Solute Flux,Tc-99,1/yr,,west,21,21,1,1,17,21,  

Solute Flux,U-235,1/yr,,west,21,21,1,1,17,21,  

#Solute Flux,Np-237,1/yr,,west,21,21,1,1,17,21,  

#Solute Flux,Sr-90,1/yr,,west,21,21,1,1,17,21,  

#Solute Flux,Zn-65,1/yr,,west,21,21,1,1,17,21,  

#Solute Flux,Eu-155,1/yr,,west,21,21,1,1,17,21,  

#  

Aqueous Volumetric Flux,m^3/yr,m^3,west,33,33,1,1,10,21,  

Solute Flux,H-3,1/yr,,west,33,33,1,1,10,21,  

Solute Flux,I-129,1/yr,,west,33,33,1,1,10,21,  

Solute Flux,Tc-99,1/yr,,west,33,33,1,1,10,21,  

Solute Flux,U-235,1/yr,,west,33,33,1,1,10,21,  

#Solute Flux,Np-237,1/yr,,west,33,33,1,1,10,21,  

#Solute Flux,Sr-90,1/yr,,west,33,33,1,1,10,21,  

#Solute Flux,Zn-65,1/yr,,west,33,33,1,1,10,21,  

#Solute Flux,Eu-155,1/yr,,west,33,33,1,1,10,21,  

#  

Aqueous Volumetric Flux,m^3/yr,m^3,west,33,33,1,1,17,21,  

Solute Flux,H-3,1/yr,,west,33,33,1,1,17,21,  

Solute Flux,I-129,1/yr,,west,33,33,1,1,17,21,

```

```

Solute Flux,Tc-99,1/yr,,west,33,33,1,1,17,21,
Solute Flux,U-235,1/yr,,west,33,33,1,1,17,21,
#Solute Flux,Np-237,1/yr,,west,33,33,1,1,17,21,
#Solute Flux,Sr-90,1/yr,,west,33,33,1,1,17,21,
#Solute Flux,Zn-65,1/yr,,west,33,33,1,1,17,21,
#Solute Flux,Eu-155,1/yr,,west,33,33,1,1,17,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,41,41,1,1,10,21,
Solute Flux,H-3,1/yr,,west,41,41,1,1,10,21,
Solute Flux,I-129,1/yr,,west,41,41,1,1,10,21,
Solute Flux,Tc-99,1/yr,,west,41,41,1,1,10,21,
Solute Flux,U-235,1/yr,,west,41,41,1,1,10,21,
#Solute Flux,Np-237,1/yr,,west,41,41,1,1,10,21,
#Solute Flux,Sr-90,1/yr,,west,41,41,1,1,10,21,
#Solute Flux,Zn-65,1/yr,,west,41,41,1,1,10,21,
#Solute Flux,Eu-155,1/yr,,west,41,41,1,1,10,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,41,41,1,1,17,21,
Solute Flux,H-3,1/yr,,west,41,41,1,1,17,21,
Solute Flux,I-129,1/yr,,west,41,41,1,1,17,21,
Solute Flux,Tc-99,1/yr,,west,41,41,1,1,17,21,
Solute Flux,U-235,1/yr,,west,41,41,1,1,17,21,
#Solute Flux,Np-237,1/yr,,west,41,41,1,1,17,21,
#Solute Flux,Sr-90,1/yr,,west,41,41,1,1,17,21,
#Solute Flux,Zn-65,1/yr,,west,41,41,1,1,17,21,
#Solute Flux,Eu-155,1/yr,,west,41,41,1,1,17,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,58,58,1,1,10,21,
Solute Flux,H-3,1/yr,,west,58,58,1,1,10,21,
Solute Flux,I-129,1/yr,,west,58,58,1,1,10,21,
Solute Flux,Tc-99,1/yr,,west,58,58,1,1,10,21,
Solute Flux,U-235,1/yr,,west,58,58,1,1,10,21,
#Solute Flux,Np-237,1/yr,,west,58,58,1,1,10,21,
#Solute Flux,Sr-90,1/yr,,west,58,58,1,1,10,21,
#Solute Flux,Zn-65,1/yr,,west,58,58,1,1,10,21,
#Solute Flux,Eu-155,1/yr,,west,58,58,1,1,10,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,58,58,1,1,17,21,
Solute Flux,H-3,1/yr,,west,58,58,1,1,17,21,
Solute Flux,I-129,1/yr,,west,58,58,1,1,17,21,
Solute Flux,Tc-99,1/yr,,west,58,58,1,1,17,21,
Solute Flux,U-235,1/yr,,west,58,58,1,1,17,21,
#Solute Flux,Np-237,1/yr,,west,58,58,1,1,17,21,
#Solute Flux,Sr-90,1/yr,,west,58,58,1,1,17,21,
#Solute Flux,Zn-65,1/yr,,west,58,58,1,1,17,21,
#Solute Flux,Eu-155,1/yr,,west,58,58,1,1,17,21,
#
~Output Control Card
48,
21,1,10,
21,1,11,
21,1,12,
21,1,13,
21,1,14,
21,1,15,
21,1,16,
21,1,17,

```

21,1,18,
21,1,19,
21,1,20,
21,1,21,
33,1,10,
33,1,11,
33,1,12,
33,1,13,
33,1,14,
33,1,15,
33,1,16,
33,1,17,
33,1,18,
33,1,19,
33,1,20,
33,1,21,
41,1,10,
41,1,11,
41,1,12,
41,1,13,
41,1,14,
41,1,15,
41,1,16,
41,1,17,
41,1,18,
41,1,19,
41,1,20,
41,1,21,
58,1,10,
58,1,11,
58,1,12,
58,1,13,
58,1,14,
58,1,15,
58,1,16,
58,1,17,
58,1,18,
58,1,19,
58,1,20,
58,1,21,
1,1,yr,m,8,8,8,
8,
aqueous saturation,,
aqueous pressure,Pa,
aqueous moisture content,,
znc aqueous vol,m/yr,
solute aqueous concentration,H-3,,
solute aqueous concentration,I-129,,
solute aqueous concentration,Tc-99,,
solute aqueous concentration,U-235,,
12,
#1,yr,
10,yr,
100,yr,
200,yr,
500,yr,
1000,yr,

1200, yr,
1500, yr,
2000, yr,
#2500, yr,
5000, yr,
10000, yr,
#20000, yr,
50000, yr,
100000, yr,
#200000, yr,
8,
aqueous saturation,,
aqueous pressure, Pa,
aqueous moisture content,,
znc aqueous vol, m/yr,
solute aqueous concentration, H-3,,
solute aqueous concentration, I-129,,
solute aqueous concentration, Tc-99,,
solute aqueous concentration, U-235,,
rock/soil type,,

E.6. DESIGN RECHARGE, SURROGATES 1 – 4 INPUT, PART B

~Simulation Title Card

1,
INEEL Lengthwise Cross Section,
WJ McMahon,
CH2M Hill Hanford,
November 29 2001,
5:00 PM PDT,
3,

This input file is the contaminant transport run for the INEEL ICDF simulation

This construction uses the geology developed by Pete Martian
The input parameters are based on PM reports

~Solution Control Card

Restart,restart,
Water w/ Solute Transport,
2,
0,day,20,yr,0.0007,yr,0.02,yr,1.25,8,1.e-6,
20,yr,30,yr,0.02,yr,0.05,yr,1.25,8,1.e-6,
8000,
0,

~Grid Card

cartesian,
60,1,98,
X Dimensions::160 m ICDF cell Total X Dimension 320 m
0.,m,6@15,m,5@10,m,2@5,m,2@5,m,
#20 m to screening model compliance point,
2@5,m,1@4.,m,1@3.,m,1@2.,m,1@1.,m,
#190 feet (or 58 m) to edge of landfill cap (less 20 m above)
2@2.,m,1@3,m,1@4.,m,2@6.,m,1@4.,m,2@3.,m,2@2,m,1@1.,m,
#190 feet (or 58 m) plus 20 m (less 58 m above)
2@2.,m,1@3,m,1@4.,m,2@3.,m,1@2,m,1@1.,m,
#190 feet (or 58 m) plus 100 m (less 78 m above)
2@2.,m,1@3,m,2@4.,m,2@5.,m,5@8.,m,1@5.,m,1@4.,m,1@3.,m,1@2,m,1@1.,m,
#One grid block to move last observation point off of boundary
2@1.,m,
Y Dimensions (Y dimension not used)
0.,m,1.,m,
Z Dimensions
#Basalt Aquifer (Total = 76 m, Begin and End Lower 61 m) 9 Rows (Ignore 0)
0.,m,2@12.,m,2@8.,m,2@6.,m,1@4.,m,1@3.,m,1@2.,m,
#Basalt Aquifer Begin First 9 m of Upper 15 m 6 Rows
6@1.5,m,
#Basalt Aquifer Begin and End Upper 6 m
(7 m or 22 ft-note 6 m saturated and 1 m above water table) 6 Rows
1@1,m,1@1,m,1@1,m,1@1,m,1@2,m,
#Basalt (16.98 m or 57 ft-note that 1 m added to aquifer layer, 17.98 m = 59 ft)
7 Rows
1@2,m,1@2.32,m,1@2.75,m,1@3.25,m,1@3,m,1@2.15,m,1@1.51,m,
#Sedimentary Interbed (7.01 m or 23 ft) 4 Rows
1@1.51,m,1@2,m,1@2,m,1@1.5,m,
#Basalt (39.93 m or 131 ft) 13 Rows

1@1.5,m,1@2,m,1@3,m,1@4,m,1@4.5,m,1@4.5,m,1@4,m,1@4,m,1@3,m,1@2.4,m,
 1@1.81,m,1@1.22,m,
 #Sedimentary Interbed (4.88 m or 16 ft) 4 Rows
 1@1.22,m,1@1.22,m,1@1.22,m,
 #Basalt (23.47 m or 77 ft) 9 Rows
 1@1.22,m,1@2,m,1@3,m,1@3.5,m,1@3.75,m,1@3.5,m,1@3,m,1@2,m,1@1.5,m,
 #Sedimentary Interbed (11.89 m or 39 ft) 6 Rows
 1@1.5,m,1@1.94,m,1@2.45,m,1@2.45,m,1@2.15,m,1@1.4,m,
 #Basalt (26.52 m or 87 ft) 13 Rows
 1@1.4,m,1@2,m,1@3,m,1@5,m,1@5,m,1@3,m,1@1.57,m,1@1.2,m,1@1,m,1@0.6,m,
 1@0.45,m,1@0.3,m,
 #Alluvium changed from 9 to 5 feet (1.52 m or 5 ft) 4 Rows
 1@0.30,m,1@0.46,m,1@0.46,m,1@0.30,m,
 #Clay Liner (0.91 m or 3 ft) 3 Rows
 1@0.30,m,1@0.31,m,1@0.30,m,
 #Operations Layer (0.91 m or 3 ft) 3 Rows
 1@0.30,m,1@0.31,m,1@0.30,m,
 #Waste (10.40 m or 34 ft adjusted to 12.56 m to account for cube vs
 trapezoid)
 # 11 Rows
 1@0.5,m,1@0.5,m,1@1,m,1@1,m,1@1.64,m,1@1.64,m,1@1.64,m,1@1,m,1@1,m,1
 @1,m,

~Rock/Soil Zonation Card

14,

#Lower 61 m of Basalt Aquifer
 Basalt Aquifer,1,60,1,1,1,9,
 #Begin First 9 m of Upper 15 m of Basalt Aquifer
 Basalt Aquifer,1,60,1,1,10,15,
 #Upper 6 m of Basalt Aquifer
 Basalt Aquifer,1,60,1,1,16,21,
 #Lowest Vadose Basalt Layer
 Basalt,1,60,1,1,22,28,
 Interbed,1,60,1,1,29,32,
 Basalt,1,60,1,1,33,45,
 Interbed,1,60,1,1,46,49,
 Basalt,1,60,1,1,50,58,
 Interbed,1,60,1,1,59,64,
 Basalt,1,60,1,1,65,77,
 Alluvium,1,60,1,1,78,81,
 Clay,1,60,1,1,82,84,
 Operation Gravelly Sand,1,60,1,1,85,87,
 Waste Gravelly Sand,1,60,1,1,88,98,

~Inactive Nodes Card

#Integer,
 2,
 16,60,1,1,1,98,
 1,15,1,1,1,84,

~Mechanical Properties Card

#Particle density = 2650 kg/m³ except for clay and old alluvium
 #Subgrade, attenuation barrier, and drain rock used in earlier models but
 #not used here
 #Basalt and interbed properties from P. Martian Screening Model
 Basalt Aquifer,,,0.06,0.06,,,Millington and Quirk,
 Interbed,,,0.487,0.487,,,Millington and Quirk,

```

Basalt,,,0.05,0.05,,,Millington and Quirk,
#
#Old Alluvium characteristics from Geotech report measurements
# sat. moisture content (0.422, 0.426); dry bulk density (1.60, 1.64 g/cm^3)
# particle density = 1.62 g/cm^3/(1-0.424) = 2.8125 g/cm^3
Alluvium,2812.5,kg/m^3,0.424,0.424,,,Millington and Quirk,
#Attenuation Barrier,,,0.400,0.400,,,Millington and Quirk,
#Clay characteristics per discussion with J. Dehner
Clay,2600,kg/m^3,0.390,0.390,,,Millington and Quirk,
#Drain Rock,,,0.400,0.400,,,Millington and Quirk,
Operation Gravelly Sand,,,0.275,0.275,,,Millington and Quirk,
#Operation Gravelly Sand dry bulk density = 120 lb/ft^3 (per J. Dehner)
#120 lb/ft^3*0.4536 kg/lb*1 ft^3/(0.3048 m/ft)^3 = 1922.25 kg/m^3
#Porosity Operation Gravelly Sand = 1-(1922.25/2650)= 0.275
Waste Gravelly Sand,,,0.266,0.266,,,Millington and Quirk,
#Waste Gravelly Sand dry bulk density = 121.5 lb/ft^3 (per J. Dehner)
#121.5 lb/ft^3*0.4536 kg/lb*1 ft^3/(0.3048 m)^3 = 1946.28 kg/m^3
#Porosity Waste Gravelly Sand = 1-(1946.28/2650)= 0.266

```

-Hydraulic Properties Card

```

#Properties from P. Martian Screening Model except old alluvium
Basalt Aquifer,9.00e+01,darcy,,,3.00e-01,darcy,
Interbed,6.7e-5,hc:cm/s,,,6.7e-5,hc:cm/s,
Basalt,9.00e+01,darcy,,,3.00e-01,darcy,
#Old Alluvium characteristics from Geotech report measurements
# sat. hydraulic conductivity (1.2e-07 cm/s, 6.2e-08 cm/s, 7.1e-08 cm/s)
Alluvium,1.2e-07,hc:cm/s,,,1.2e-07,hc:cm/s,
#Subgrade,1e-04,hc:cm/s,,,1e-04,hc:cm/s,
#Attenuation Barrier,1e-07,hc:cm/s,,,1e-07,hc:cm/s,
Clay,1e-07,hc:cm/s,,,1e-07,hc:cm/s,
#Drain Rock,3.0e-01,hc:cm/s,,,3.0e-01,hc:cm/s,
Operation Gravelly Sand,1e-04,hc:cm/s,,,1e-04,hc:cm/s,
Waste Gravelly Sand,1e-03,hc:cm/s,,,1e-03,hc:cm/s,

```

-Saturation Function Card

```

#Parameters from P. Martian Screening Model except old alluvium
#alpha, n, theta R, m
#m only specified for basalts, otherwise default m = 1 - 1/n
Basalt Aquifer,Nonhysteretic van Genuchten,4.0,1/m,4.5,0.0002,0.7777778,
Interbed,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.142.,
Basalt,Nonhysteretic van Genuchten,4.0,1/m,4.5,0.0002,0.7777778,
#Old Alluvium characteristics from RETC fitting of Geotech report
measurements
Alluvium,Nonhysteretic van Genuchten,0.595,1/m,1.09,0.142.,
#Subgrade,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.142.,
#Attenuation Barrier,Nonhysteretic van Genuchten,0.800,1/m,1.090,0.07.,
Clay,Nonhysteretic van Genuchten,0.800,1/m,1.109,0.07.,
#Drain Rock,Nonhysteretic van Genuchten,493,1/m,2.190,0.005.,
Operation Gravelly Sand,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.083.,
Waste Gravelly Sand,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.072.,
#

```

-Aqueous Relative Permeability Card

```

#m only specified for basalts, otherwise default m = 1 - 1/n
Basalt Aquifer,Mualem,1.9,
Interbed,Mualem.,
Basalt,Mualem,1.9,
Alluvium,Mualem,,
```

```

#Subgrade,Mualem,
#Attenuation Barrier,Mualem,
Clay,Mualem,
#Drain Rock,Mualem,
Operation Gravelly Sand,Mualem,
Waste Gravelly Sand,Mualem,
#
~Solute/Fluid Interactions Card
4,
H-3,conventional,1.0e-09,m^2/s,noncontinuous...
I-129,conventional,1.0e-09,m^2/s,noncontinuous...
Tc-99,conventional,1.0e-09,m^2/s,noncontinuous...
U-235,conventional,1.0e-09,m^2/s,noncontinuous...
#Np-237,conventional,1.0e-09,m^2/s,noncontinuous...
#Sr-90,conventional,1.0e-09,m^2/s,noncontinuous...
#Zn-65,conventional,1.0e-09,m^2/s,noncontinuous...
#Eu-155,conventional,1.0e-09,m^2/s,noncontinuous...
0,
#
~Solute/Porous Media Interaction Card
Basalt Aquifer,6.0,m,3.0,m,
H-3,0.0,cm^3/g,
I-129,0.0,cm^3/g,
Tc-99,0.008,cm^3/g,
U-235,0.24,cm^3/g,
#Np-237,0.32,cm^3/g,
#Sr-90,0.48,cm^3/g,
#Zn-65,0.64,cm^3/g,
#Eu-155,314,cm^3/g,
#
Interbed,5.0,m,0,m,
H-3,0.0,cm^3/g,
I-129,0.0,cm^3/g,
Tc-99,0.2,cm^3/g,
U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
#Sr-90,24.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
#Eu-155,340,cm^3/g,
#
Basalt,5.0,m,0,m,
H-3,0.0,cm^3/g,
I-129,0.0,cm^3/g,
Tc-99,0.0,cm^3/g,
U-235,0.0,cm^3/g,
#Np-237,0.0,cm^3/g,
#Sr-90,0.0,cm^3/g,
#Zn-65,0.0,cm^3/g,
#Eu-155,0.0,cm^3/g,
#
#Subgrade,5.0,m,0,m,
#
Alluvium,5.0,m,0,m,
H-3,0.0,cm^3/g,
I-129,0.0,cm^3/g,
Tc-99,0.2,cm^3/g,
U-235,6.0,cm^3/g,

```

```

#Np-237,8.0,cm^3/g,
#Sr-90,24.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
#Eu-155,340,cm^3/g,
#
#Attenuation Barrier,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,1.0,cm^3/g,
#Tc-99,1.0,cm^3/g,
#U-235,63.0,cm^3/g,
#Np-237,55.0,cm^3/g,
#Sr-90,200.0,cm^3/g,
#Zn-65,2400.0,cm^3/g,
#Eu-155,340,cm^3/g,
#
Clay,5.0,m,0,m,
H-3,0.0,cm^3/g,
I-129,1.0,cm^3/g,
Tc-99,1.0,cm^3/g,
U-235,63.0,cm^3/g,
#Np-237,55.0,cm^3/g,
#Sr-90,200.0,cm^3/g,
#Zn-65,2400.0,cm^3/g,
#Eu-155,340,cm^3/g,
#
#Drain Rock,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.2,cm^3/g,
#U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
#Sr-90,24.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
#Eu-155,340,cm^3/g,
#
Operation Gravelly Sand,5.0,m,0,m,
H-3,0.0,cm^3/g,
I-129,0.0,cm^3/g,
Tc-99,0.2,cm^3/g,
U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
#Sr-90,24.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
#Eu-155,340,cm^3/g,
#
Waste Gravelly Sand,5.0,m,0,m,
H-3,0.0,cm^3/g,
I-129,0.0,cm^3/g,
Tc-99,0.2,cm^3/g,
U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
#Sr-90,12.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
#Eu-155,340,cm^3/g,
#
~Initial Conditions Card
Gas Pressure,Aqueous Pressure,

```

```

9,
Aqueous Pressure,.,.,.,1,60,1,1,1,98,
Solute Volume Overwrite,H-3,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,I-129,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Tc-99,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,U-235,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,Np-237,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,Sr-90,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,Zn-65,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,Eu-155,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#
Solute Volume Overwrite,H-3,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,I-129,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Tc-99,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,U-235,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,Np-237,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,Sr-90,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,Zn-65,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,Eu-155,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,

~Boundary Conditions Card
3,
#
top,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#0.0001 m/yr * 1.74 ICDF Recharge Ratio = 0.000174 m/yr
1,15,1,1,98,98,1,
0,day,-0.000174,m/yr,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
east,seepage face,outflow,outflow,outflow,outflow,
#Emplace seepage face to account for leachate drain removal
#Base of seepage face cell (Height = 0.3 m) set to atmospheric pressure
#P = 101325 - 0.15 m * 9793.52 = 99855.97
15,15,1,1,85,85,1,
0,day,99855.97,Pa,.....#
#
west,seepage face,outflow,outflow,outflow,outflow,
#Emplace seepage face to account for leachate drain removal
#Base of seepage face cell (Height = 0.3 m) set to atmospheric pressure
#P = 101325 - 0.15 m * 9793.52 = 99855.97
1,1,1,1,85,85,1,
0,day,99855.97,Pa,.....#
#
~Surface Flux Card
15,
Aqueous Volumetric Flux,m^3/yr,m^3,top,1,15,1,1,85,85,
Solute Flux,H-3,1/yr,,top,1,15,1,1,85,85,
Solute Flux,I-129,1/yr,,top,1,15,1,1,85,85,
Solute Flux,Tc-99,1/yr,,top,1,15,1,1,85,85,
Solute Flux,U-235,1/yr,,top,1,15,1,1,85,85,
#Solute Flux,Np-237,1/yr,,top,1,15,1,1,85,85,
#Solute Flux,Sr-90,1/yr,,top,1,15,1,1,85,85,
#Solute Flux,Zn-65,1/yr,,top,1,15,1,1,85,85,
#Solute Flux,Eu-155,1/yr,,top,1,15,1,1,85,85,

```

```
#  
Aqueous Volumetric Flux,m^3/yr,m^3,west,1,1,1,1,85,85,  
Solute Flux,H-3,1/yr,,west,1,1,1,1,85,85,  
Solute Flux,I-129,1/yr,,west,1,1,1,1,85,85,  
Solute Flux,Tc-99,1/yr,,west,1,1,1,1,85,85,  
Solute Flux,U-235,1/yr,,west,1,1,1,1,85,85,  
#  
Aqueous Volumetric Flux,m^3/yr,m^3,east,15,15,1,1,85,85,  
Solute Flux,H-3,1/yr,,east,15,15,1,1,85,85,  
Solute Flux,I-129,1/yr,,east,15,15,1,1,85,85,  
Solute Flux,Tc-99,1/yr,,east,15,15,1,1,85,85,  
Solute Flux,U-235,1/yr,,east,15,15,1,1,85,85,  
#  
~Output Control Card  
12,  
1,1,85,  
5,1,85,  
10,1,85,  
15,1,85,  
1,1,88,  
5,1,88,  
10,1,88,  
15,1,88,  
1,1,98,  
5,1,98,  
10,1,98,  
15,1,98,  
1,1,yr,m,8,8,8,  
8,  
aqueous saturation,,  
aqueous pressure,Pa,  
aqueous moisture content,,  
znc aqueous vol,m/yr,  
solute aqueous concentration,H-3,,  
solute aqueous concentration,I-129,,  
solute aqueous concentration,Tc-99,,  
solute aqueous concentration,U-235,,  
30,  
1,yr,  
2,yr,  
3,yr,  
4,yr,  
5,yr,  
6,yr,  
7,yr,  
8,yr,  
9,yr,  
10,yr,  
11,yr,  
12,yr,  
13,yr,  
14,yr,  
15,yr,  
16,yr,  
17,yr,  
18,yr,  
19,yr,
```

20, yr,
21, yr,
22, yr,
23, yr,
24, yr,
25, yr,
26, yr,
27, yr,
28, yr,
29, yr,
30, yr,
8,
aqueous saturation,,
aqueous pressure, Pa,
aqueous moisture content,,
znc aqueous vol,m/yr,
solute aqueous concentration,H-3,,
solute aqueous concentration,I-129,,
solute aqueous concentration,Tc-99,,
solute aqueous concentration,U-235,,
rock/soil type,,

E.7. DESIGN RECHARGE, SURROGATES 5 – 8 INPUT, PART A

-Simulation Title Card
1,
B Pond Lengthwise Cross Section,
WJ McMahon,
CH2M Hill Hanford,
July 23 2001,
10:00 AM PDT,
3,
This input file is the contaminant transport run for the INEEL ICDF simulation
This construction uses the geology developed by Pete Martian
The input parameters are based on PM reports

-Solution Control Card

Restart,restart,
Water w/ Solute Transport,
9,
0,day,20,yr,0.0007,yr,0.02,yr,1.25,8,1.e-6,
20,yr,50,yr,0.02,yr,0.05,yr,1.25,8,1.e-6,
50,yr,100,yr,0.05,yr,0.10,yr,1.25,8,1.e-6,
100,yr,500,yr,0.10,yr,0.50,yr,1.25,8,1.e-6,
500,yr,1000,yr,0.50,yr,2,yr,1.25,8,1.e-6,
1000,yr,5000,yr,2,yr,10,yr,1.25,8,1.e-6,
5000,yr,10000,yr,10,yr,100,yr,1.25,8,1.e-6,
10000,yr,100000,yr,100,yr,1000,yr,1.25,8,1.e-6,
100000,yr,1000000,yr,1000,yr,10000,yr,1.25,8,1.e-6,
8000,
0,

-Grid Card

cartesian,
60,1,98,
X Dimensions:::160 m ICDF cell Total X Dimension 320 m
0.,m,6@15,m,5@10,m,2@5,m,2@5,m,
#20 m to screening model compliance point,
2@5,m,1@4.,m,1@3.,m,1@2.,m,1@1.,m,
#190 feet (or 58 m) to edge of landfill cap (less 20 m above)
2@2.,m,1@3,m,1@4.,m,2@6.,m,1@4.,m,2@3.,m,2@2,m,1@1.,m,
#190 feet (or 58 m) plus 20 m (less 58 m above)
2@2.,m,1@3,m,1@4.,m,2@3.,m,1@2,m,1@1.,m,
#190 feet (or 58 m) plus 100 m (less 78 m above)
2@2.,m,1@3,m,2@4.,m,2@5.,m,5@8.,m,1@5.,m,1@4.,m,1@3.,m,1@2,m,1@1.,m,
#One grid block to move last observation point off of boundary
2@1.,m,
Y Dimensions (Y dimension not used)
0.,m,1.,m,
Z Dimensions
#Basalt Aquifer (Total = 76 m, Begin and End Lower 61 m) 9 Rows (Ignore 0)
0.,m,2@12.,m,2@8.,m,2@6.,m,1@4.,m,1@3.,m,1@2.,m,
#Basalt Aquifer Begin First 9 m of Upper 15 m 6 Rows
6@1.5,m,
#Basalt Aquifer Begin and End Upper 6 m
(7 m or 22 ft-note 6 m saturated and 1 m above water table) 6 Rows
1@1,m,1@1,m,1@1,m,1@1,m,1@2,m,

```

#Basalt (16.98 m or 57 ft-note that 1 m added to aquifer layer, 17.98 m = 59
ft)
# 7 Rows
1@2,m,1@2.32,m,1@2.75,m,1@3.25,m,1@3,m,1@2.15,m,1@1.51,m,
#Sedimentary Interbed (7.01 m or 23 ft) 4 Rows
1@1.51,m,1@2,m,1@2,m,1@1.5,m,
#Basalt (39.93 m or 131 ft) 13 Rows
1@1.5,m,1@2,m,1@3,m,1@4,m,1@4,m,1@4.5,m,1@4.5,m,1@4,m,1@4,m,1@3,m,1@2.4,m,
1@1.81,m,1@1.22,m,
#Sedimentary Interbed (4.88 m or 16 ft) 4 Rows
1@1.22,m,1@1.22,m,1@1.22,m,1@1.22,m,
#Basalt (23.47 m or 77 ft) 9 Rows
1@1.22,m,1@2,m,1@3,m,1@3.5,m,1@3.75,m,1@3.5,m,1@3,m,1@2,m,1@1.5,m,
#Sedimentary Interbed (11.89 m or 39 ft) 6 Rows
1@1.5,m,1@1.94,m,1@2.45,m,1@2.45,m,1@2.15,m,1@1.4,m,
#Basalt (26.52 m or 87 ft) 13 Rows
1@1.4,m,1@2,m,1@2,m,1@3,m,1@5,m,1@5,m,1@3,m,1@1.57,m,1@1.2,m,1@1,m,1@0.6,m,
1@0.45,m,1@0.3,m,
#Alluvium changed from 9 to 5 feet (1.52 m or 5 ft) 4 Rows
1@0.30,m,1@0.46,m,1@0.46,m,1@0.30,m,
#Clay Liner (0.91 m or 3 ft) 3 Rows
1@0.30,m,1@0.31,m,1@0.30,m,
#Operations Layer (0.91 m or 3 ft) 3 Rows
1@0.30,m,1@0.31,m,1@0.30,m,
#Waste (10.40 m or 34 ft adjusted to 12.56 m to account for cube vs
trapezoid)
# 11 Rows
1@0.5,m,1@0.5,m,1@1,m,1@1,m,1@1.64,m,1@1.64,m,1@1.64,m,1@1.64,m,1@1,m,1
@1,m,

```

~Rock/Soil Zonation Card

14,

#Lower 61 m of Basalt Aquifer

Basalt Aquifer,1,60,1,1,1,9,

#Begin First 9 m of Upper 15 m of Basalt Aquifer

Basalt Aquifer,1,60,1,1,10,15,

#Upper 6 m of Basalt Aquifer

Basalt Aquifer,1,60,1,1,16,21,

#Lowest Vadose Basalt Layer

Basalt,1,60,1,1,22,28,

Interbed,1,60,1,1,29,32,

Basalt,1,60,1,1,33,45,

Interbed,1,60,1,1,46,49,

Basalt,1,60,1,1,50,58,

Interbed,1,60,1,1,59,64,

Basalt,1,60,1,1,65,77,

Alluvium,1,60,1,1,78,81,

Clay,1,60,1,1,82,84,

Operation Gravelly Sand,1,60,1,1,85,87,

Waste Gravelly Sand,1,60,1,1,88,98,

~Inactive Nodes Card

#Integer,

1,

16,60,1,1,22,98,

~Mechanical Properties Card

```

#Particle density = 2650 kg/m^3 except for clay and old alluvium
#Subgrade, attenuation barrier, and drain rock used in earlier models but
#not used here
#Basalt and interbed properties from P. Martian Screening Model
Basalt Aquifer,,,0.06,0.06,,,Millington and Quirk,
Interbed,,0.487,0.487,,,Millington and Quirk,
Basalt,,,0.05,0.05,,,Millington and Quirk,
#
#Old Alluvium characteristics from Geotech report measurements
# sat. moisture content (0.422, 0.426); dry bulk density (1.60, 1.64 g/cm^3)
# particle density = 1.62 g/cm^3/(1-0.424) = 2.8125 g/cm^3
Alluvium,2812.5,kg/m^3,0.424,0.424,,,Millington and Quirk,
#Attenuation Barrier,,,0.400,0.400,,,Millington and Quirk,
#Clay characteristics per discussion with J. Dehner
Clay,2600,kg/m^3,0.390,0.390,,,Millington and Quirk,
#Drain Rock,,,0.400,0.400,,,Millington and Quirk,
Operation Gravelly Sand,,,0.275,0.275,,,Millington and Quirk,
#Operation Gravelly Sand dry bulk density = 120 lb/ft^3 (per J. Dehner)
#120 lb/ft^3*0.4536 kg/lb*1 ft^3/(0.3048 m/ft)^3 = 1922.25 kg/m^3
#Porosity Operation Gravelly Sand = 1-(1922.25/2650)= 0.275
Waste Gravelly Sand,,,0.266,0.266,,,Millington and Quirk,
#Waste Gravelly Sand dry bulk density = 121.5 lb/ft^3 (per J. Dehner)
#121.5 lb/ft^3*0.4536 kg/lb*1 ft^3/(0.3048 m)^3 = 1946.28 kg/m^3
#Porosity Waste Gravelly Sand = 1-(1946.28/2650)= 0.266

```

-Hydraulic Properties Card

```

#Properties from P. Martian Screening Model except old alluvium
Basalt Aquifer,9.00e+01,darcy,,,3.00e-01,darcy,
Interbed,6.7e-5,hc:cm/s,,,6.7e-5,hc:cm/s,
Basalt,9.00e+01,darcy,,,3.00e-01,darcy,
#Old Alluvium characteristics from Geotech report measurements
# sat. hydraulic conductivity (1.2e-07 cm/s, 6.2e-08 cm/s, 7.1e-08 cm/s)
Alluvium,1.2e-07,hc:cm/s,,,1.2e-07,hc:cm/s,
#Subgrade,1e-04,hc:cm/s,,,1e-04,hc:cm/s,
#Attenuation Barrier,1e-07,hc:cm/s,,,1e-07,hc:cm/s,
Clay,1e-07,hc:cm/s,,,1e-07,hc:cm/s,
#Drain Rock,3.0e-01,hc:cm/s,,,3.0e-01,hc:cm/s,
Operation Gravelly Sand,1e-04,hc:cm/s,,,1e-04,hc:cm/s,
Waste Gravelly Sand,1e-03,hc:cm/s,,,1e-03,hc:cm/s,

```

-Saturation Function Card

```

#Parameters from P. Martian Screening Model except old alluvium
#alpha, n, theta R, m
#m only specified for basalts, otherwise default m = 1 - 1/n
Basalt Aquifer,Nonhysteretic van Genuchten,4.0,1/m,4.5,0.0002,0.7777778,
Interbed,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.142,,
Basalt,Nonhysteretic van Genuchten,4.0,1/m,4.5,0.0002,0.7777778,
#Old Alluvium characteristics from RETC fitting of Geotech report
measurements
Alluvium,Nonhysteretic van Genuchten,0.595,1/m,1.09,0.142,,
#Subgrade,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.142,,
#Attenuation Barrier,Nonhysteretic van Genuchten,0.800,1/m,1.090,0.07,,
Clay,Nonhysteretic van Genuchten,0.800,1/m,1.109,0.07,,
#Drain Rock,Nonhysteretic van Genuchten,493,1/m,2.190,0.005,,
Operation Gravelly Sand,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.083,,
Waste Gravelly Sand,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.072,,
#

```

```

~Aqueous Relative Permeability Card
#m only specified for basalts, otherwise default m = 1 - 1/n
Basalt Aquifer,Mualem,1.9,
Interbed,Mualem.,
Basalt,Mualem,1.9,
Alluvium,Mualem.,
#Subgrade,Mualem.,
#Attenuation Barrier,Mualem.,
Clay,Mualem.,
#Drain Rock,Mualem.,
Operation Gravelly Sand,Mualem.,
Waste Gravelly Sand,Mualem.,
#
~Solute/Fluid Interactions Card
4,
#H-3,conventional,1.0e-09,m^2/s,noncontinuous,,
#I-129,conventional,1.0e-09,m^2/s,noncontinuous,,
#Tc-99,conventional,1.0e-09,m^2/s,noncontinuous,,
#U-235,conventional,1.0e-09,m^2/s,noncontinuous,,
Np-237,conventional,1.0e-09,m^2/s,noncontinuous,,
Sr-90,conventional,1.0e-09,m^2/s,noncontinuous,,
Zn-65,conventional,1.0e-09,m^2/s,noncontinuous,,
Eu-155,conventional,1.0e-09,m^2/s,noncontinuous,,
0,
#
~Solute/Porous Media Interaction Card
Basalt Aquifer,6.0,m,3.0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.008,cm^3/g,
#U-235,0.24,cm^3/g,
Np-237,0.32,cm^3/g,
Sr-90,0.48,cm^3/g,
Zn-65,0.64,cm^3/g,
Eu-155,314,cm^3/g,
#
Interbed,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.2,cm^3/g,
#U-235,6.0,cm^3/g,
Np-237,8.0,cm^3/g,
Sr-90,12.0,cm^3/g,
Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
Basalt,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.0,cm^3/g,
#U-235,0.0,cm^3/g,
Np-237,0.0,cm^3/g,
Sr-90,0.0,cm^3/g,
Zn-65,0.0,cm^3/g,
Eu-155,0.0,cm^3/g,
#

```

```

#Subgrade,5.0,m,0,m,
#
Alluvium,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.2,cm^3/g,
#U-235,6.0,cm^3/g,
Np-237,8.0,cm^3/g,
Sr-90,24.0,cm^3/g,
Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
#Attenuation Barrier,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,1.0,cm^3/g,
#Tc-99,1.0,cm^3/g,
#U-235,63.0,cm^3/g,
#Np-237,55.0,cm^3/g,
#Sr-90,200.0,cm^3/g,
#Zn-65,2400.0,cm^3/g,
#Eu-155,340,cm^3/g,
#
Clay,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,1.0,cm^3/g,
#Tc-99,1.0,cm^3/g,
#U-235,63.0,cm^3/g,
Np-237,55.0,cm^3/g,
Sr-90,200.0,cm^3/g,
Zn-65,2400.0,cm^3/g,
Eu-155,340,cm^3/g,
#
#Drain Rock,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.2,cm^3/g,
#U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
#Sr-90,24.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
#Eu-155,340,cm^3/g,
#
Operation Gravelly Sand,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.2,cm^3/g,
#U-235,6.0,cm^3/g,
Np-237,8.0,cm^3/g,
Sr-90,12.0,cm^3/g,
Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
Waste Gravelly Sand,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.2,cm^3/g,
#U-235,6.0,cm^3/g,

```

```

Np-237,8.0,cm^3/g,
Sr-90,12.0,cm^3/g,
Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
~Initial Conditions Card
Gas Pressure,Aqueous Pressure,
9,
Aqueous Pressure,,,,,,1,60,1,1,1,83,
#$olute Volume Overwrite,H-3,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
#$olute Volume Overwrite,I-129,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
#$olute Volume Overwrite,Tc-99,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
#$olute Volume Overwrite,U-235,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Np-237,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Sr-90,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Zn-65,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Eu-155,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
#
#$olute Volume Overwrite,H-3,2.0e+03,1/m^3,0,,0,,1,15,1,1,88,98,
#$olute Volume Overwrite,I-129,2.0e+03,1/m^3,0,,0,,1,15,1,1,88,98,
#$olute Volume Overwrite,Tc-99,2.0e+03,1/m^3,0,,0,,1,15,1,1,88,98,
#$olute Volume Overwrite,U-235,2.0e+03,1/m^3,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Np-237,1946.28,1/m^3,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Sr-90,1946.28,1/m^3,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Zn-65,1946.28,1/m^3,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Eu-155,1946.28,1/m^3,0,,0,,1,15,1,1,88,98,

~Boundary Conditions Card
4,
#
top,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#0.0001 m/yr * 1.74 ICDF Recharge Ratio = 0.000174 m/yr
1,15,1,1,98,98,1,
0,day,-0.000174,m/yr,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
west,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
1,1,1,1,1,20,1,
0,day,0.06,m/day,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
west,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
1,1,1,1,21,1,
0,day,0.03,m/day,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
east,hydraulic gradient,outflow,outflow,outflow,outflow,
#Hold head constant to keep h ~ 5 m at compliance point

```

```

60,60,1,1,1,21,1,
0,day,786871.34,Pa.....,
#
~Surface Flux Card
50,
Aqueous Volumetric Flux,m^3/yr,m^3,bottom,1,15,1,1,82,82,
#Solute Flux,H-3,1/yr,,bottom,1,15,1,1,82,82,
#Solute Flux,I-129,1/yr,,bottom,1,15,1,1,82,82,
#Solute Flux,Tc-99,1/yr,,bottom,1,15,1,1,82,82,
#Solute Flux,U-235,1/yr,,bottom,1,15,1,1,82,82,
Solute Flux,Np-237,1/yr,,bottom,1,15,1,1,82,82,
Solute Flux,Sr-90,1/yr,,bottom,1,15,1,1,82,82,
Solute Flux,Zn-65,1/yr,,bottom,1,15,1,1,82,82,
Solute Flux,Eu-155,1/yr,,bottom,1,15,1,1,82,82,
#
Aqueous Volumetric Flux,m^3/yr,m^3,bottom,1,15,1,1,22,22,
#Solute Flux,H-3,1/yr,,bottom,1,15,1,1,22,22,
#Solute Flux,I-129,1/yr,,bottom,1,15,1,1,22,22,
#Solute Flux,Tc-99,1/yr,,bottom,1,15,1,1,22,22,
#Solute Flux,U-235,1/yr,,bottom,1,15,1,1,22,22,
Solute Flux,Np-237,1/yr,,bottom,1,15,1,1,22,22,
Solute Flux,Sr-90,1/yr,,bottom,1,15,1,1,22,22,
Solute Flux,Zn-65,1/yr,,bottom,1,15,1,1,22,22,
Solute Flux,Eu-155,1/yr,,bottom,1,15,1,1,22,22,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,21,21,1,1,10,21,
#Solute Flux,H-3,1/yr,,west,21,21,1,1,10,21,
#Solute Flux,I-129,1/yr,,west,21,21,1,1,10,21,
#Solute Flux,Tc-99,1/yr,,west,21,21,1,1,10,21,
#Solute Flux,U-235,1/yr,,west,21,21,1,1,10,21,
Solute Flux,Np-237,1/yr,,west,21,21,1,1,10,21,
Solute Flux,Sr-90,1/yr,,west,21,21,1,1,10,21,
Solute Flux,Zn-65,1/yr,,west,21,21,1,1,10,21,
Solute Flux,Eu-155,1/yr,,west,21,21,1,1,10,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,21,21,1,1,17,21,
#Solute Flux,H-3,1/yr,,west,21,21,1,1,17,21,
#Solute Flux,I-129,1/yr,,west,21,21,1,1,17,21,
#Solute Flux,Tc-99,1/yr,,west,21,21,1,1,17,21,
#Solute Flux,U-235,1/yr,,west,21,21,1,1,17,21,
Solute Flux,Np-237,1/yr,,west,21,21,1,1,17,21,
Solute Flux,Sr-90,1/yr,,west,21,21,1,1,17,21,
Solute Flux,Zn-65,1/yr,,west,21,21,1,1,17,21,
Solute Flux,Eu-155,1/yr,,west,21,21,1,1,17,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,33,33,1,1,10,21,
#Solute Flux,H-3,1/yr,,west,33,33,1,1,10,21,
#Solute Flux,I-129,1/yr,,west,33,33,1,1,10,21,
#Solute Flux,Tc-99,1/yr,,west,33,33,1,1,10,21,
#Solute Flux,U-235,1/yr,,west,33,33,1,1,10,21,
Solute Flux,Np-237,1/yr,,west,33,33,1,1,10,21,
Solute Flux,Sr-90,1/yr,,west,33,33,1,1,10,21,
Solute Flux,Zn-65,1/yr,,west,33,33,1,1,10,21,
Solute Flux,Eu-155,1/yr,,west,33,33,1,1,10,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,33,33,1,1,17,21,
#Solute Flux,H-3,1/yr,,west,33,33,1,1,17,21,

```

```

#Solute Flux,I-129,1/yr.,west,33,33,1,1,17,21,
#Solute Flux,Tc-99,1/yr.,west,33,33,1,1,17,21,
#Solute Flux,U-235,1/yr.,west,33,33,1,1,17,21,
Solute Flux,Np-237,1/yr.,west,33,33,1,1,17,21,
Solute Flux,Sr-90,1/yr.,west,33,33,1,1,17,21,
Solute Flux,Zn-65,1/yr.,west,33,33,1,1,17,21,
Solute Flux,Eu-155,1/yr.,west,33,33,1,1,17,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,41,41,1,1,10,21,
#Solute Flux,H-3,1/yr.,west,41,41,1,1,10,21,
#Solute Flux,I-129,1/yr.,west,41,41,1,1,10,21,
#Solute Flux,Tc-99,1/yr.,west,41,41,1,1,10,21,
#Solute Flux,U-235,1/yr.,west,41,41,1,1,10,21,
Solute Flux,Np-237,1/yr.,west,41,41,1,1,10,21,
Solute Flux,Sr-90,1/yr.,west,41,41,1,1,10,21,
Solute Flux,Zn-65,1/yr.,west,41,41,1,1,10,21,
Solute Flux,Eu-155,1/yr.,west,41,41,1,1,10,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,41,41,1,1,17,21,
#Solute Flux,H-3,1/yr.,west,41,41,1,1,17,21,
#Solute Flux,I-129,1/yr.,west,41,41,1,1,17,21,
#Solute Flux,Tc-99,1/yr.,west,41,41,1,1,17,21,
#Solute Flux,U-235,1/yr.,west,41,41,1,1,17,21,
Solute Flux,Np-237,1/yr.,west,41,41,1,1,17,21,
Solute Flux,Sr-90,1/yr.,west,41,41,1,1,17,21,
Solute Flux,Zn-65,1/yr.,west,41,41,1,1,17,21,
Solute Flux,Eu-155,1/yr.,west,41,41,1,1,17,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,58,58,1,1,10,21,
#Solute Flux,H-3,1/yr.,west,58,58,1,1,10,21,
#Solute Flux,I-129,1/yr.,west,58,58,1,1,10,21,
#Solute Flux,Tc-99,1/yr.,west,58,58,1,1,10,21,
#Solute Flux,U-235,1/yr.,west,58,58,1,1,10,21,
Solute Flux,Np-237,1/yr.,west,58,58,1,1,10,21,
Solute Flux,Sr-90,1/yr.,west,58,58,1,1,10,21,
Solute Flux,Zn-65,1/yr.,west,58,58,1,1,10,21,
Solute Flux,Eu-155,1/yr.,west,58,58,1,1,10,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,58,58,1,1,17,21,
#Solute Flux,H-3,1/yr.,west,58,58,1,1,17,21,
#Solute Flux,I-129,1/yr.,west,58,58,1,1,17,21,
#Solute Flux,Tc-99,1/yr.,west,58,58,1,1,17,21,
#Solute Flux,U-235,1/yr.,west,58,58,1,1,17,21,
Solute Flux,Np-237,1/yr.,west,58,58,1,1,17,21,
Solute Flux,Sr-90,1/yr.,west,58,58,1,1,17,21,
Solute Flux,Zn-65,1/yr.,west,58,58,1,1,17,21,
Solute Flux,Eu-155,1/yr.,west,58,58,1,1,17,21,
#
~Output Control Card
48,
21,1,10,
21,1,11,
21,1,12,
21,1,13,
21,1,14,
21,1,15,

```

21,1,16,
21,1,17,
21,1,18,
21,1,19,
21,1,20,
21,1,21,
33,1,10,
33,1,11,
33,1,12,
33,1,13,
33,1,14,
33,1,15,
33,1,16,
33,1,17,
33,1,18,
33,1,19,
33,1,20,
33,1,21,
41,1,10,
41,1,11,
41,1,12,
41,1,13,
41,1,14,
41,1,15,
41,1,16,
41,1,17,
41,1,18,
41,1,19,
41,1,20,
41,1,21,
58,1,10,
58,1,11,
58,1,12,
58,1,13,
58,1,14,
58,1,15,
58,1,16,
58,1,17,
58,1,18,
58,1,19,
58,1,20,
58,1,21,
1,1,yr,m,8,8,8,
8,
aqueous saturation,,
aqueous pressure,Pa,
aqueous moisture content,,
znc aqueous vol,m/yr,
solute aqueous concentration,Np-237,,
solute aqueous concentration,Sr-90,,
solute aqueous concentration,Zn-65,,
solute aqueous concentration,Eu-155,,
12,
#1,yr,
10,yr,
100,yr,
200,yr,

500, yr,
1000, yr,
1200, yr,
1500, yr,
2000, yr,
#2500, yr,
5000, yr,
10000, yr,
#20000, yr,
50000, yr,
100000, yr,
#200000, yr,
8,
aqueous saturation,,
aqueous pressure, Pa,
aqueous moisture content,,
znc aqueous vol, m/yr,
solute aqueous concentration, Np-237,,
solute aqueous concentration, Sr-90,,
solute aqueous concentration, Zn-65,,
solute aqueous concentration, Eu-155,,
rock/soil type,,

E.8. DESIGN RECHARGE, SURROGATES 5 – 8 INPUT, PART B

```
~Simulation Title Card
1,
INEEL Lengthwise Cross Section,
WJ McMahon,
CH2M Hill Hanford,
November 29 2001,
5:00 PM PDT,
3,
This input file is the contaminant transport run for the INEEL ICDF
simulation
This construction uses the geology developed by Pete Martian
The input parameters are based on PM reports

~Solution Control Card
Restart,restart,
Water w/ Solute Transport,
2,
0,day,20,yr,0.0007,yr,0.02,yr,1.25,8,1.e-6,
20,yr,30,yr,0.02,yr,0.05,yr,1.25,8,1.e-6,
8000,
0,

~Grid Card
cartesian,
60,1,98,
# X Dimensions::160 m ICDF cell Total X Dimension 320 m
0.,m,6@15,m,5@10,m,2@5,m,2@5,m,
#20 m to screening model compliance point,
2@5,m,1@4.,m,1@3.,m,1@2.,m,1@1.,m,
#190 feet (or 58 m) to edge of landfill cap (less 20 m above)
2@2.,m,1@3,m,1@4.,m,2@6.,m,1@4.,m,2@3.,m,2@2,m,1@1.,m,
#190 feet (or 58 m) plus 20 m (less 58 m above)
2@2.,m,1@3,m,1@4.,m,2@3.,m,1@2,m,1@1.,m,
#190 feet (or 58 m) plus 100 m (less 78 m above)
2@2.,m,1@3,m,2@4.,m,2@5.,m,5@8.,m,1@5.,m,1@4.,m,1@3.,m,1@2,m,1@1.,m,
#One grid block to move last observation point off of boundary
2@1.,m,
# Y Dimensions (Y dimension not used)
0.,m,1.,m,
# Z Dimensions
#Basalt Aquifer (Total = 76 m, Begin and End Lower 61 m) 9 Rows (Ignore 0)
0.,m,2@12.,m,2@8.,m,2@6.,m,1@4.,m,1@3.,m,1@2.,m,
#Basalt Aquifer Begin First 9 m of Upper 15 m 6 Rows
6@1.5,m,
#Basalt Aquifer Begin and End Upper 6 m
# (7 m or 22 ft-note 6 m saturated and 1 m above water table) 6 Rows
1@1,m,1@1,m,1@1,m,1@1,m,1@2,m,
#Basalt (16.98 m or 57 ft-note that 1 m added to aquifer layer, 17.98 m = 59
ft)
# 7 Rows
1@2,m,1@2.32,m,1@2.75,m,1@3.25,m,1@3,m,1@2.15,m,1@1.51,m,
#Sedimentary Interbed (7.01 m or 23 ft) 4 Rows
1@1.51,m,1@2,m,1@2,m,1@1.5,m,
#Basalt (39.93 m or 131 ft) 13 Rows
```

1@1.5,m,1@2,m,1@3,m,1@4,m,1@4.5,m,1@4.5,m,1@4,m,1@4,m,1@3,m,1@2.4,m,
 1@1.81,m,1@1.22,m,
 #Sedimentary Interbed (4.88 m or 16 ft) 4 Rows
 1@1.22,m,1@1.22,m,1@1.22,m,1@1.22,m,
 #Basalt (23.47 m or 77 ft) 9 Rows
 1@1.22,m,1@2,m,1@3,m,1@3.5,m,1@3.75,m,1@3.5,m,1@3,m,1@2,m,1@1.5,m,
 #Sedimentary Interbed (11.89 m or 39 ft) 6 Rows
 1@1.5,m,1@1.94,m,1@2.45,m,1@2.45,m,1@2.15,m,1@1.4,m,
 #Basalt (26.52 m or 87 ft) 13 Rows
 1@1.4,m,1@2,m,1@2,m,1@3,m,1@5,m,1@5,m,1@3,m,1@1.57,m,1@1.2,m,1@1,m,1@0.6,m,
 1@0.45,m,1@0.3,m,
 #Alluvium changed from 9 to 5 feet (1.52 m or 5 ft) 4 Rows
 1@0.30,m,1@0.46,m,1@0.46,m,1@0.30,m,
 #Clay Liner (0.91 m or 3 ft) 3 Rows
 1@0.30,m,1@0.31,m,1@0.30,m,
 #Operations Layer (0.91 m or 3 ft) 3 Rows
 1@0.30,m,1@0.31,m,1@0.30,m,
 #Waste (10.40 m or 34 ft adjusted to 12.56 m to account for cube vs
 trapezoid)
 # 11 Rows
 1@0.5,m,1@0.5,m,1@1,m,1@1,m,1@1.64,m,1@1.64,m,1@1.64,m,1@1.64,m,1@1,m,1@1,m,
 @1,m,

-Rock/Soil Zonation Card

14,
 #Lower 61 m of Basalt Aquifer
 Basalt Aquifer,1,60,1,1,1,9,
 #Begin First 9 m of Upper 15 m of Basalt Aquifer
 Basalt Aquifer,1,60,1,1,10,15,
 #Upper 6 m of Basalt Aquifer
 Basalt Aquifer,1,60,1,1,16,21,
 #Lowest Vadose Basalt Layer
 Basalt,1,60,1,1,22,28,
 Interbed,1,60,1,1,29,32,
 Basalt,1,60,1,1,33,45,
 Interbed,1,60,1,1,46,49,
 Basalt,1,60,1,1,50,58,
 Interbed,1,60,1,1,59,64,
 Basalt,1,60,1,1,65,77,
 Alluvium,1,60,1,1,78,81,
 Clay,1,60,1,1,82,84,
 Operation Gravelly Sand,1,60,1,1,85,87,
 Waste Gravelly Sand,1,60,1,1,88,98,

#

-Inactive Nodes Card

#Integer,
 2,
 16,60,1,1,1,98,
 1,15,1,1,1,84,
 #

-Mechanical Properties Card

#Particle density = 2650 kg/m³ except for clay and old alluvium
 #Subgrade, attenuation barrier, and drain rock used in earlier models but
 #not used here
 #Basalt and interbed properties from P. Martian Screening Model
 Basalt Aquifer,,,0.06,0.06,,,Millington and Quirk,
 Interbed,,,0.487,0.487,,,Millington and Quirk,

```

Basalt,,,0.05,0.05,,,Millington and Quirk,
#
#Old Alluvium characteristics from Geotech report measurements
# sat. moisture content (0.422, 0.426); dry bulk density (1.60, 1.64 g/cm^3)
# particle density = 1.62 g/cm^3/(1-0.424) = 2.8125 g/cm^3
Alluvium,2812.5,kg/m^3,0.424,0.424,,,Millington and Quirk,
#Attenuation Barrier,,,0.400,0.400,,,Millington and Quirk,
#Clay characteristics per discussion with J. Dehner
Clay,2600,kg/m^3,0.390,0.390,,,Millington and Quirk,
#Drain Rock,,,0.400,0.400,,,Millington and Quirk,
Operation Gravelly Sand,,,0.275,0.275,,,Millington and Quirk,
#Operation Gravelly Sand dry bulk density = 120 lb/ft^3 (per J. Dehner)
#120 lb/ft^3*0.4536 kg/lb*1 ft^3/(0.3048 m/ft)^3 = 1922.25 kg/m^3
#Porosity Operation Gravelly Sand = 1-(1922.25/2650)= 0.275
Waste Gravelly Sand,,,0.266,0.266,,,Millington and Quirk,
#Waste Gravelly Sand dry bulk density = 121.5 lb/ft^3 (per J. Dehner)
#121.5 lb/ft^3*0.4536 kg/lb*1 ft^3/(0.3048 m)^3 = 1946.28 kg/m^3
#Porosity Waste Gravelly Sand = 1-(1946.28/2650)= 0.266

```

-Hydraulic Properties Card

```

#Properties from P. Martian Screening Model except old alluvium
Basalt Aquifer,9.00e+01,darcy,,,3.00e-01,darcy,
Interbed,6.7e-5,hc:cm/s,,,6.7e-5,hc:cm/s,
Basalt,9.00e+01,darcy,,,3.00e-01,darcy,
#Old Alluvium characteristics from Geotech report measurements
# sat. hydraulic conductivity (1.2e-07 cm/s, 6.2e-08 cm/s, 7.1e-08 cm/s)
Alluvium,1.2e-07,hc:cm/s,,,1.2e-07,hc:cm/s,
#Subgrade,1e-04,hc:cm/s,,,1e-04,hc:cm/s,
#Attenuation Barrier,1e-07,hc:cm/s,,,1e-07,hc:cm/s,
Clay,1e-07,hc:cm/s,,,1e-07,hc:cm/s,
#Drain Rock,3.0e-01,hc:cm/s,,,3.0e-01,hc:cm/s,
Operation Gravelly Sand,1e-04,hc:cm/s,,,1e-04,hc:cm/s,
Waste Gravelly Sand,1e-03,hc:cm/s,,,1e-03,hc:cm/s,

```

-Saturation Function Card

```

#Parameters from P. Martian Screening Model except old alluvium
#alpha, n, theta R, m
#m only specified for basalts, otherwise default m = 1 - 1/n
Basalt Aquifer,Nonhysteretic van Genuchten,4.0,1/m,4.5,0.0002,0.7777778,
Interbed,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.142,,,
Basalt,Nonhysteretic van Genuchten,4.0,1/m,4.5,0.0002,0.7777778,
#Old Alluvium characteristics from RETC fitting of Geotech report
measurements
Alluvium,Nonhysteretic van Genuchten,0.595,1/m,1.09,0.142,,,
#Subgrade,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.142,,,
#Attenuation Barrier,Nonhysteretic van Genuchten,0.800,1/m,1.090,0.07,,,
Clay,Nonhysteretic van Genuchten,0.800,1/m,1.109,0.07,,,
#Drain Rock,Nonhysteretic van Genuchten,493,1/m,2.190,0.005,,,
Operation Gravelly Sand,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.083,,,
Waste Gravelly Sand,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.072,,,
#

```

-Aqueous Relative Permeability Card

```

#m only specified for basalts, otherwise default m = 1 - 1/n
Basalt Aquifer,Mualem,1.9,
Interbed,Mualem,,,
Basalt,Mualem,1.9,
Alluvium,Mualem,,
```

```

#Subgrade,Mualem,
#Attenuation Barrier,Mualem,
Clay,Mualem,
#Drain Rock,Mualem,
Operation Gravelly Sand,Mualem,
Waste Gravelly Sand,Mualem,
#
-Solute/Fluid Interactions Card
4,
#H-3,conventional,1.0e-09,m^2/s,noncontinuous,,
#I-129,conventional,1.0e-09,m^2/s,noncontinuous,,
#Tc-99,conventional,1.0e-09,m^2/s,noncontinuous,,
#U-235,conventional,1.0e-09,m^2/s,noncontinuous,,
Np-237,conventional,1.0e-09,m^2/s,noncontinuous,,
Sr-90,conventional,1.0e-09,m^2/s,noncontinuous,,
Zn-65,conventional,1.0e-09,m^2/s,noncontinuous,,
Eu-155,conventional,1.0e-09,m^2/s,noncontinuous,,
0,
#
-Solute/Porous Media Interaction Card
Basalt Aquifer,6.0,m,3.0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.008,cm^3/g,
#U-235,0.24,cm^3/g,
Np-237,0.32,cm^3/g,
Sr-90,0.48,cm^3/g,
Zn-65,0.64,cm^3/g,
Eu-155,314,cm^3/g,
#
Interbed,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.2,cm^3/g,
#U-235,6.0,cm^3/g,
Np-237,8.0,cm^3/g,
Sr-90,12.0,cm^3/g,
Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
Basalt,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.0,cm^3/g,
#U-235,0.0,cm^3/g,
Np-237,0.0,cm^3/g,
Sr-90,0.0,cm^3/g,
Zn-65,0.0,cm^3/g,
Eu-155,0.0,cm^3/g,
#
#Subgrade,5.0,m,0,m,
#
Alluvium,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.2,cm^3/g,

```

```

#U-235,6.0,cm^3/g,
Np-237,8.0,cm^3/g,
Sr-90,24.0,cm^3/g,
Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
#Attenuation Barrier,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,1.0,cm^3/g,
#Tc-99,1.0,cm^3/g,
#U-235,63.0,cm^3/g,
#Np-237,55.0,cm^3/g,
#Sr-90,200.0,cm^3/g,
#Zn-65,2400.0,cm^3/g,
#Eu-155,340,cm^3/g,
#
Clay,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,1.0,cm^3/g,
#Tc-99,1.0,cm^3/g,
#U-235,63.0,cm^3/g,
Np-237,55.0,cm^3/g,
Sr-90,200.0,cm^3/g,
Zn-65,2400.0,cm^3/g,
Eu-155,340,cm^3/g,
#
#Drain Rock,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.2,cm^3/g,
#U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
#Sr-90,24.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
#Eu-155,340,cm^3/g,
#
Operation Gravelly Sand,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.2,cm^3/g,
#U-235,6.0,cm^3/g,
Np-237,8.0,cm^3/g,
Sr-90,12.0,cm^3/g,
Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
Waste Gravelly Sand,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129,0.0,cm^3/g,
#Tc-99,0.2,cm^3/g,
#U-235,6.0,cm^3/g,
Np-237,8.0,cm^3/g,
Sr-90,12.0,cm^3/g,
Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
~Initial Conditions Card

```

```

Gas Pressure,Aqueous Pressure,
9,
Aqueous Pressure,,,,1,60,1,1,1,98,
#Solute Volume Overwrite,H-3,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,I-129,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,Tc-99,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,U-235,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Np-237,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Sr-90,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Zn-65,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Eu-155,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
#
#Solute Volume Overwrite,H-3,2.0e+03,1/m^3,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,I-129,2.0e+03,1/m^3,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,Tc-99,2.0e+03,1/m^3,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,U-235,2.0e+03,1/m^3,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Np-237,1946.28,1/m^3,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Sr-90,1946.28,1/m^3,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Zn-65,1946.28,1/m^3,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Eu-155,1946.28,1/m^3,0,,0,,1,15,1,1,88,98,

~Boundary Conditions Card
3,
#
top,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#0.0001 m/yr * 1.74 ICDF Recharge Ratio = 0.000174 m/yr
1,15,1,1,98,98,1,
0,day,-0.000174,m/yr,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
east,seepage face,outflow,outflow,outflow,outflow,
#Emplace seepage face to account for leachate drain removal
#Base of seepage face cell (Height = 0.3 m) set to atmospheric pressure
#P = 101325 - 0.15 m * 9793.52 = 99855.97
15,15,1,1,85,85,1,
0,day,99855.97,Pa,.....,
#
west,seepage face,outflow,outflow,outflow,outflow,
#Emplace seepage face to account for leachate drain removal
#Base of seepage face cell (Height = 0.3 m) set to atmospheric pressure
#P = 101325 - 0.15 m * 9793.52 = 99855.97
1,1,1,1,85,85,1,
0,day,99855.97,Pa,.....,
#
#
~Surface Flux Card
15,
Aqueous Volumetric Flux,m^3/yr,m^3,top,1,15,1,1,85,85,
#Solute Flux,H-3,1/yr,,top,1,15,1,1,85,85,
#Solute Flux,I-129,1/yr,,top,1,15,1,1,85,85,
#Solute Flux,Tc-99,1/yr,,top,1,15,1,1,85,85,
#Solute Flux,U-235,1/yr,,top,1,15,1,1,85,85,
#Solute Flux,Np-237,1/yr,,top,1,15,1,1,85,85,
#Solute Flux,Sr-90,1/yr,,top,1,15,1,1,85,85,

```

Solute Flux,Zn-65,1/yr,,top,1,15,1,1,85,85,
Solute Flux,Eu-155,1/yr,,top,1,15,1,1,85,85,

Aqueous Volumetric Flux,m^3/yr,m^3,west,1,1,1,1,85,85,
Solute Flux,Np-237,1/yr,,west,1,1,1,1,85,85,
Solute Flux,Sr-90,1/yr,,west,1,1,1,1,85,85,
Solute Flux,Zn-65,1/yr,,west,1,1,1,1,85,85,
Solute Flux,Eu-155,1/yr,,west,1,1,1,1,85,85,

Aqueous Volumetric Flux,m^3/yr,m^3,east,15,15,1,1,85,85,
Solute Flux,Np-237,1/yr,,east,15,15,1,1,85,85,
Solute Flux,Sr-90,1/yr,,east,15,15,1,1,85,85,
Solute Flux,Zn-65,1/yr,,east,15,15,1,1,85,85,
Solute Flux,Eu-155,1/yr,,east,15,15,1,1,85,85,

~Output Control Card
12,
1,1,85,
5,1,85,
10,1,85,
15,1,85,
1,1,88,
5,1,88,
10,1,88,
15,1,88,
1,1,98,
5,1,98,
10,1,98,
15,1,98,
1,1,yr,m,8,8,8,
8,
aqueous saturation,,
aqueous pressure,Pa,
aqueous moisture content,,
znc aqueous vol,m/yr,
solute aqueous concentration,Np-237,,
solute aqueous concentration,Sr-90,,
solute aqueous concentration,Zn-65,,
.solute aqueous concentration,Eu-155,,
30,
1,yr,
2,yr,
3,yr,
4,yr,
5,yr,
6,yr,
7,yr,
8,yr,
9,yr,
10,yr,
11,yr,
12,yr,
13,yr,
14,yr,
15,yr,
16,yr,
17,yr,

18, yr,
19, yr,
20, yr,
21, yr,
22, yr,
23, yr,
24, yr,
25, yr,
26, yr,
27, yr,
28, yr,
29, yr,
30, yr,
8,
aqueous saturation,,
aqueous pressure, Pa,
aqueous moisture content,,
znc aqueous vol, m/yr,
solute aqueous concentration, Np-237,,
solute aqueous concentration, Sr-90,,
solute aqueous concentration, Zn-65,,
solute aqueous concentration, Eu-155,,
rock/soil type,,

E.9. DESIGN RECHARGE, SURROGATES 9 – 12 INPUT, PART A

-Simulation Title Card

1,
B Pond Lengthwise Cross Section,
WJ McMahon,
CH2M Hill Hanford,
July 23 2001,
10:00 AM PDT,
3,

This input file is the contaminant transport run for the INEEL ICDF simulation

This construction uses the geology developed by Pete Martian
The input parameters are based on PM reports

-Solution Control Card

Restart,restart,
Water w/ Solute Transport,
9,
0,day,20,yr,0.0007,yr,0.02,yr,1.25,8,1.e-6,
20,yr,50,yr,0.02,yr,0.05,yr,1.25,8,1.e-6,
50,yr,100,yr,0.05,yr,0.10,yr,1.25,8,1.e-6,
100,yr,500,yr,0.10,yr,0.5,yr,1.25,8,1.e-6,
500,yr,1000,yr,0.5,yr,2,yr,1.25,8,1.e-6,
1000,yr,5000,yr,2,yr,10,yr,1.25,8,1.e-6,
5000,yr,10000,yr,10,yr,100,yr,1.25,8,1.e-6,
10000,yr,100000,yr,100,yr,1000,yr,1.25,8,1.e-6,
100000,yr,1000000,yr,1000,yr,10000,yr,1.25,8,1.e-6,
8000,
0,

-Grid Card

cartesian,
60,1,98,
X Dimensions::160 m ICDF cell Total X Dimension 320 m
0.,m,6@15,m,5@10,m,2@5,m,2@5,m,
#20 m to screening model compliance point,
2@5,m,1@4.,m,1@3.,m,1@2.,m,1@1.,m,
#190 feet (or 58 m) to edge of landfill cap (less 20 m above)
2@2.,m,1@3,m,1@4.,m,2@6.,m,1@4.,m,2@3.,m,2@2,m,1@1.,m,
#190 feet (or 58 m) plus 20 m (less 58 m above)
2@2.,m,1@3,m,1@4.,m,2@3.,m,1@2,m,1@1.,m,
#190 feet (or 58 m) plus 100 m (less 78 m above)
2@2.,m,1@3,m,2@4.,m,2@5.,m,5@8.,m,1@5.,m,1@4.,m,1@3.,m,1@2,m,1@1.,m,
#One grid block to move last observation point off of boundary
2@1.,m,
Y Dimensions (Y dimension not used)
0.,m,1.,m,
Z Dimensions
#Basalt Aquifer (Total = 76 m, Begin and End Lower 61 m) 9 Rows (Ignore 0)
0.,m,2@12.,m,2@8.,m,2@6.,m,1@4.,m,1@3.,m,1@2.,m,
#Basalt Aquifer Begin First 9 m of Upper 15 m 6 Rows
6@1.5,m,
#Basalt Aquifer Begin and End Upper 6 m
(7 m or 22 ft-note 6 m saturated and 1 m above water table) 6 Rows
1@1,m,1@1,m,1@1,m,1@1,m,1@2,m,

```

#Basalt (16.98 m or 57 ft-note that 1 m added to aquifer layer, 17.98 m = 59
ft)
# 7 Rows
1@2,m,1@2.32,m,1@2.75,m,1@3.25,m,1@3,m,1@2.15,m,1@1.51,m,
#Sedimentary Interbed (7.01 m or 23 ft) 4 Rows
1@1.51,m,1@2,m,1@2,m,1@1.5,m,
#Basalt (39.93 m or 131 ft) 13 Rows
1@1.5,m,1@2,m,1@3,m,1@4,m,1@4,m,1@4.5,m,1@4.5,m,1@4,m,1@4,m,1@3,m,1@2.4,m,
1@1.81,m,1@1.22,m,
#Sedimentary Interbed (4.88 m or 16 ft) 4 Rows
1@1.22,m,1@1.22,m,1@1.22,m,1@1.22,m,
#Basalt (23.47 m or 77 ft) 9 Rows
1@1.22,m,1@2,m,1@3,m,1@3.5,m,1@3.75,m,1@3.5,m,1@3,m,1@2,m,1@1.5,m,
#Sedimentary Interbed (11.89 m or 39 ft) 6 Rows
1@1.5,m,1@1.94,m,1@2.45,m,1@2.45,m,1@2.15,m,1@1.4,m,
#Basalt (26.52 m or 87 ft) 13 Rows
1@1.4,m,1@2,m,1@2,m,1@3,m,1@5,m,1@5,m,1@3,m,1@1.57,m,1@1.2,m,1@1,m,1@0.6,m,
1@0.45,m,1@0.3,m,
#Alluvium changed from 9 to 5 feet (1.52 m or 5 ft) 4 Rows
1@0.30,m,1@0.46,m,1@0.46,m,1@0.30,m,
#Clay Liner (0.91 m or 3 ft) 3 Rows
1@0.30,m,1@0.31,m,1@0.30,m,
#Operations Layer (0.91 m or 3 ft) 3 Rows
1@0.30,m,1@0.31,m,1@0.30,m,
#Waste (10.40 m or 34 ft adjusted to 12.56 m to account for cube vs
trapezoid)
# 11 Rows
1@0.5,m,1@0.5,m,1@1,m,1@1,m,1@1.64,m,1@1.64,m,1@1.64,m,1@1.64,m,1@1,m,1@1,m,1
@1,m,

```

~Rock/Soil Zonation Card

```

14,
#Lower 61 m of Basalt Aquifer
Basalt Aquifer,1,60,1,1,1,9,
#Begin First 9 m of Upper 15 m of Basalt Aquifer
Basalt Aquifer,1,60,1,1,10,15,
#Upper 6 m of Basalt Aquifer
Basalt Aquifer,1,60,1,1,16,21,
#Lowest Vadose Basalt Layer
Basalt,1,60,1,1,22,28,
Interbed,1,60,1,1,29,32,
Basalt,1,60,1,1,33,45,
Interbed,1,60,1,1,46,49,
Basalt,1,60,1,1,50,58,
Interbed,1,60,1,1,59,64,
Basalt,1,60,1,1,65,77,
Alluvium,1,60,1,1,78,81,
Clay,1,60,1,1,82,84,
Operation Gravelly Sand,1,60,1,1,85,87,
Waste Gravelly Sand,1,60,1,1,88,98,

```

~Inactive Nodes Card

```

#Integer,
1,
16,60,1,1,22,98,

```

~Mechanical Properties Card

```

#Particle density = 2650 kg/m^3 except for clay and old alluvium
#Subgrade, attenuation barrier, and drain rock used in earlier models but
#not used here
#Basalt and interbed properties from P. Martian Screening Model
Basalt Aquifer,,,0.06,0.06,,,Millington and Quirk,
Interbed,,,0.487,0.487,,,Millington and Quirk,
Basalt,,,0.05,0.05,,,Millington and Quirk,
#
#Old Alluvium characteristics from Geotech report measurements
# sat. moisture content (0.422, 0.426); dry bulk density (1.60, 1.64 g/cm^3)
# particle density = 1.62 g/cm^3/(1-0.424) = 2.8125 g/cm^3
Alluvium,2812.5,kg/m^3,0.424,0.424,,,Millington and Quirk,
#Attenuation Barrier,,,0.400,0.400,,,Millington and Quirk,
#Clay characteristics per discussion with J. Dehner
Clay,2600,kg/m^3,0.390,0.390,,,Millington and Quirk,
#Drain Rock,,,0.400,0.400,,,Millington and Quirk,
Operation Gravelly Sand,,,0.275,0.275,,,Millington and Quirk,
#Operation Gravelly Sand dry bulk density = 120 lb/ft^3 (per J. Dehner)
#120 lb/ft^3*0.4536 kg/lb*1 ft^3/(0.3048 m/ft)^3 = 1922.25 kg/m^3
#Porosity Operation Gravelly Sand = 1-(1922.25/2650)= 0.275
Waste Gravelly Sand,,,0.266,0.266,,,Millington and Quirk,
#Waste Gravelly Sand dry bulk density = 121.5 lb/ft^3 (per J. Dehner)
#121.5 lb/ft^3*0.4536 kg/lb*1 ft^3/(0.3048 m)^3 = 1946.28 kg/m^3
#Porosity Waste Gravelly Sand = 1-(1946.28/2650)= 0.266

```

-Hydraulic Properties Card

```

#Properties from P. Martian Screening Model except old alluvium
Basalt Aquifer,9.00e+01,darcy,,,3.00e-01,darcy,
Interbed,6.7e-5,hc:cm/s,,,6.7e-5,hc:cm/s,
Basalt,9.00e+01,darcy,,,3.00e-01,darcy,
#Old Alluvium characteristics from Geotech report measurements
# sat. hydraulic conductivity (1.2e-07 cm/s, 6.2e-08 cm/s, 7.1e-08 cm/s)
Alluvium,1.2e-07,hc:cm/s,,,1.2e-07,hc:cm/s,
#Subgrade,1e-04,hc:cm/s,,,1e-04,hc:cm/s,
#Attenuation Barrier,1e-07,hc:cm/s,,,1e-07,hc:cm/s,
Clay,1e-07,hc:cm/s,,,1e-07,hc:cm/s,
#Drain Rock,3.0e-01,hc:cm/s,,,3.0e-01,hc:cm/s,
Operation Gravelly Sand,1e-04,hc:cm/s,,,1e-04,hc:cm/s,
Waste Gravelly Sand,1e-03,hc:cm/s,,,1e-03,hc:cm/s,

```

-Saturation Function Card

```

#Parameters from P. Martian Screening Model except old alluvium
#alpha, n, theta R, m
#m only specified for basalts, otherwise default m = 1 - 1/n
Basalt Aquifer,Nonhysteretic van Genuchten,4.0,1/m,4.5,0.0002,0.7777778,
Interbed,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.142.,
Basalt,Nonhysteretic van Genuchten,4.0,1/m,4.5,0.0002,0.7777778,
#Old Alluvium characteristics from RETC fitting of Geotech report
measurements
Alluvium,Nonhysteretic van Genuchten,0.595,1/m,1.09,0.142.,
#Subgrade,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.142.,
#Attenuation Barrier,Nonhysteretic van Genuchten,0.800,1/m,1.090,0.07.,
Clay,Nonhysteretic van Genuchten,0.800,1/m,1.109,0.07.,
#Drain Rock,Nonhysteretic van Genuchten,493,1/m,2.190,0.005.,
Operation Gravelly Sand,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.083.,
Waste Gravelly Sand,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.072.,
#

```

```

~Aqueous Relative Permeability Card
#m only specified for basalts, otherwise default m = 1 - 1/n
Basalt Aquifer,Mualem,1.9,
Interbed,Mualem.,
Basalt,Mualem,1.9,
Alluvium,Mualem.,
#Subgrade,Mualem.,
#Attenuation Barrier,Mualem.,
Clay,Mualem.,
#Drain Rock,Mualem.,
Operation Gravelly Sand,Mualem.,
Waste Gravelly Sand,Mualem.,
#
-Solute/Fluid Interactions Card
4,
#H-3,conventional,1.0e-09,m^2/s,noncontinuous...
I-129A,conventional,1.0e-09,m^2/s,noncontinuous...
I-129B,conventional,1.0e-09,m^2/s,noncontinuous...
#U-235,conventional,1.0e-09,m^2/s,noncontinuous...
#Np-237,conventional,1.0e-09,m^2/s,noncontinuous...
Sr-90,conventional,1.0e-09,m^2/s,noncontinuous...
#Zn-65,conventional,1.0e-09,m^2/s,noncontinuous...
Eu-155,conventional,1.0e-09,m^2/s,noncontinuous...
0,
#
~Solute/Porous Media Interaction Card
Basalt Aquifer,6.0,m,3.0,m,
#H-3,0.0,cm^3/g,
I-129A,0.0,cm^3/g,
I-129B,0.0,cm^3/g,
#U-235,0.24,cm^3/g,
#Np-237,0.32,cm^3/g,
Sr-90,0.48,cm^3/g,
#Zn-65,0.64,cm^3/g,
Eu-155,13.6,cm^3/g,
#
Interbed,5.0,m,0,m,
#H-3,0.0,cm^3/g,
I-129A,0.0,cm^3/g,
I-129B,0.1,cm^3/g,
#U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
Sr-90,12.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
Basalt,5.0,m,0,m,
#H-3,0.0,cm^3/g,
I-129A,0.0,cm^3/g,
I-129B,0.0,cm^3/g,
#U-235,0.0,cm^3/g,
#Np-237,0.0,cm^3/g,
Sr-90,0.0,cm^3/g,
#Zn-65,0.0,cm^3/g,
Eu-155,0,cm^3/g,
#
#Subgrade,5.0,m,0,m,

```

```

#
Alluvium,5.0,m,0,m,
#H-3,0.0,cm^3/g,
I-129A,0.0,cm^3/g,
I-129B,0.1,cm^3/g,
#U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
Sr-90,24.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
#Attenuation Barrier,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129A,1.0,cm^3/g,
#I-129B,1.0,cm^3/g,
#U-235,63.0,cm^3/g,
#Np-237,55.0,cm^3/g,
#Sr-90,200.0,cm^3/g,
#Zn-65,2400.0,cm^3/g,
#Eu-155,340,cm^3/g,
#
Clay,5.0,m,0,m,
#H-3,0.0,cm^3/g,
I-129A,1.0,cm^3/g,
I-129B,1.0,cm^3/g,
#U-235,63.0,cm^3/g,
#Np-237,55.0,cm^3/g,
Sr-90,200.0,cm^3/g,
#Zn-65,2400.0,cm^3/g,
Eu-155,340,cm^3/g,
#
#Drain Rock,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129A,0.0,cm^3/g,
#I-129B,0.1,cm^3/g,
#U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
#Sr-90,24.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
#Eu-155,340,cm^3/g,
#
Operation Gravelly Sand,5.0,m,0,m,
#H-3,0.0,cm^3/g,
I-129A,0.0,cm^3/g,
I-129B,0.1,cm^3/g,
#U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
Sr-90,12.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
Waste Gravelly Sand,5.0,m,0,m,
#H-3,0.0,cm^3/g,
I-129A,0.1,cm^3/g,
I-129B,0.1,cm^3/g,
#U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,

```

```

Sr-90,12.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
~Initial Conditions Card
Gas Pressure,Aqueous Pressure,
9,
Aqueous Pressure,,,,,,,1,60,1,1,1,98,
#Solute Volume Overwrite,H-3,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,I-129A,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,I-129B,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,U-235,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,Np-237,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Sr-90,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,Zn-65,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Eu-155,0.0,1/m^3,0,,0,,0,,1,60,1,1,1,98,
#
#Solute Volume Overwrite,H-3,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,I-129A,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,I-129B,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,U-235,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,Np-237,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Sr-90,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,Zn-65,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Eu-155,1946.28,1/m^3,0,,0,,0,,1,15,1,1,88,98,

~Boundary Conditions Card
4,
#
top,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#0.0001 m/yr * 1.74 ICDF Recharge Ratio = 0.000174 m/yr
1,15,1,1,98,98,1,
0,day,-0.000174,m/yr,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
west,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
1,1,1,1,1,20,1,
0,day,0.06,m/day,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
west,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
1,1,1,1,21,1,
0,day,0.03,m/day,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
east,hydraulic gradient,outflow,outflow,outflow,outflow,
#Hold head constant to keep h ~ 5 m at compliance point
60,60,1,1,1,21,1,

```



```

Solute Flux,I-129B,1/yr,,west,33,33,1,1,17,21,
#Solute Flux,U-235,1/yr,,west,33,33,1,1,17,21,
#Solute Flux,Np-237,1/yr,,west,33,33,1,1,17,21,
Solute Flux,Sr-90,1/yr,,west,33,33,1,1,17,21,
#Solute Flux,Zn-65,1/yr,,west,33,33,1,1,17,21,
Solute Flux,Eu-155,1/yr,,west,33,33,1,1,17,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,41,41,1,1,10,21,
#Solute Flux,H-3,1/yr,,west,41,41,1,1,10,21,
Solute Flux,I-129A,1/yr,,west,41,41,1,1,10,21,
Solute Flux,I-129B,1/yr,,west,41,41,1,1,10,21,
#Solute Flux,U-235,1/yr,,west,41,41,1,1,10,21,
#Solute Flux,Np-237,1/yr,,west,41,41,1,1,10,21,
Solute Flux,Sr-90,1/yr,,west,41,41,1,1,10,21,
#Solute Flux,Zn-65,1/yr,,west,41,41,1,1,10,21,
Solute Flux,Eu-155,1/yr,,west,41,41,1,1,10,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,41,41,1,1,17,21,
#Solute Flux,H-3,1/yr,,west,41,41,1,1,17,21,
Solute Flux,I-129A,1/yr,,west,41,41,1,1,17,21,
Solute Flux,I-129B,1/yr,,west,41,41,1,1,17,21,
#Solute Flux,U-235,1/yr,,west,41,41,1,1,17,21,
#Solute Flux,Np-237,1/yr,,west,41,41,1,1,17,21,
Solute Flux,Sr-90,1/yr,,west,41,41,1,1,17,21,
#Solute Flux,Zn-65,1/yr,,west,41,41,1,1,17,21,
Solute Flux,Eu-155,1/yr,,west,41,41,1,1,17,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,58,58,1,1,10,21,
#Solute Flux,H-3,1/yr,,west,58,58,1,1,10,21,
Solute Flux,I-129A,1/yr,,west,58,58,1,1,10,21,
Solute Flux,I-129B,1/yr,,west,58,58,1,1,10,21,
#Solute Flux,U-235,1/yr,,west,58,58,1,1,10,21,
#Solute Flux,Np-237,1/yr,,west,58,58,1,1,10,21,
Solute Flux,Sr-90,1/yr,,west,58,58,1,1,10,21,
#Solute Flux,Zn-65,1/yr,,west,58,58,1,1,10,21,
Solute Flux,Eu-155,1/yr,,west,58,58,1,1,10,21,
#
Aqueous Volumetric Flux,m^3/yr,m^3,west,58,58,1,1,17,21,
#Solute Flux,H-3,1/yr,,west,58,58,1,1,17,21,
Solute Flux,I-129A,1/yr,,west,58,58,1,1,17,21,
Solute Flux,I-129B,1/yr,,west,58,58,1,1,17,21,
#Solute Flux,U-235,1/yr,,west,58,58,1,1,17,21,
#Solute Flux,Np-237,1/yr,,west,58,58,1,1,17,21,
Solute Flux,Sr-90,1/yr,,west,58,58,1,1,17,21,
#Solute Flux,Zn-65,1/yr,,west,58,58,1,1,17,21,
Solute Flux,Eu-155,1/yr,,west,58,58,1,1,17,21,
#
~Output Control Card
48,
21,1,10,
21,1,11,
21,1,12,
21,1,13,
21,1,14,
21,1,15,
21,1,16,
21,1,17,
```

21,1,18,
21,1,19,
21,1,20,
21,1,21,
33,1,10,
33,1,11,
33,1,12,
33,1,13,
33,1,14,
33,1,15,
33,1,16,
33,1,17,
33,1,18,
33,1,19,
33,1,20,
33,1,21,
41,1,10,
41,1,11,
41,1,12,
41,1,13,
41,1,14,
41,1,15,
41,1,16,
41,1,17,
41,1,18,
41,1,19,
41,1,20,
41,1,21,
58,1,10,
58,1,11,
58,1,12,
58,1,13,
58,1,14,
58,1,15,
58,1,16,
58,1,17,
58,1,18,
58,1,19,
58,1,20,
58,1,21,
1,1,yr,m,8,8,8,
8,
aqueous saturation,,
aqueous pressure,Pa,
aqueous moisture content,,
znc aqueous vol,m/yr,
solute aqueous concentration,I-129A,,
solute aqueous concentration,I-129B,,
solute aqueous concentration,Sr-90,,
solute aqueous concentration,Eu-155,,
12,
#1,yr,
10,yr,
100,yr,
200,yr,
500,yr,
1000,yr,

1200, yr,
1500, yr,
2000, yr,
#2500, yr,
5000, yr,
10000, yr,
#20000, yr,
50000, yr,
100000, yr,
#200000, yr,
8,
aqueous saturation,,
aqueous pressure, Pa,
aqueous moisture content,,
znc aqueous vol, m/yr,
solute aqueous concentration, I-129A,,
solute aqueous concentration, I-129B,,
solute aqueous concentration, Sr-90,,
solute aqueous concentration, Eu-155,,
rock/soil type,,

E.10. DESIGN RECHARGE, SURROGATES 9 – 12 INPUT, PART B

```
-Simulation Title Card
1,
INEEL Lengthwise Cross Section,
WJ McMahon,
CH2M Hill Hanford,
November 29 2001,
5:00 PM PDT,
3,
This input file is the contaminant transport run for the INEEL ICDF
simulation
This construction uses the geology developed by Pete Martian
The input parameters are based on PM reports

~Solution Control Card
Restart,restart,
Water w/ Solute Transport,
2,
0,day;20,yr,0.0007,yr,0.02,yr,1.25,8,1.e-6,
20,yr,30,yr,0.02,yr,0.05,yr,1.25,8,1.e-6,
8000,
0,

~Grid Card
cartesian,
60,1,98,
# X Dimensions::160 m ICDF cell Total X Dimension 320 m
0.,m,6@15,m,5@10,m,2@5,m,2@5,m,
#20 m to screening model compliance point,
2@5,m,1@4.,m,1@3.,m,1@2.,m,1@1.,m,
#190 feet (or 58 m) to edge of landfill cap (less 20 m above)
2@2.,m,1@3,m,1@4.,m,2@6.,m,1@4.,m,2@3.,m,2@2,m,1@1.,m,
#190 feet (or 58 m) plus 20 m (less 58 m above)
2@2.,m,1@3,m,1@4.,m,2@3.,m,1@2,m,1@1.,m,
#190 feet (or 58 m) plus 100 m (less 78 m above)
2@2.,m,1@3,m,2@4.,m,2@5.,m,5@8.,m,1@5.,m,1@4.,m,1@3.,m,1@2,m,1@1.,m,
#One grid block to move last observation point off of boundary
2@1.,m,
# Y Dimensions (Y dimension not used)
0.,m,1.,m,
# Z Dimensions
#Basalt Aquifer (Total = 76 m, Begin and End Lower 61 m) 9 Rows (Ignore 0)
0.,m,2@12.,m,2@8.,m,2@6.,m,1@4.,m,1@3.,m,1@2.,m,
#Basalt Aquifer Begin First 9 m of Upper 15 m 6 Rows
6@1.5,m,
#Basalt Aquifer Begin and End Upper 6 m
# (7 m or 22 ft-note 6 m saturated and 1 m above water table) 6 Rows
1@1,m,1@1,m,1@1,m,1@1,m,1@2,m,
#Basalt (16.98 m or 57 ft-note that 1 m added to aquifer layer, 17.98 m = 59
ft)
# 7 Rows
1@2,m,1@2.32,m,1@2.75,m,1@3.25,m,1@3,m,1@2.15,m,1@1.51,m,
#Sedimentary Interbed (7.01 m or 23 ft) 4 Rows
1@1.51,m,1@2,m,1@2,m,1@1.5,m,
#Basalt (39.93 m or 131 ft) 13 Rows
```

1@1.5,m,1@2,m,1@3,m,1@4,m,1@4.5,m,1@4.5,m,1@4,m,1@4,m,1@3,m,1@2.4,m,
 1@1.81,m,1@1.22,m,
 #Sedimentary Interbed (4.88 m or 16 ft) 4 Rows
 1@1.22,m,1@1.22,m,1@1.22,m,1@1.22,m,
 #Basalt (23.47 m or 77 ft) 9 Rows
 1@1.22,m,1@2,m,1@3,m,1@3.5,m,1@3.75,m,1@3.5,m,1@3,m,1@2,m,1@1.5,m,
 #Sedimentary Interbed (11.89 m or 39 ft) 6 Rows
 1@1.5,m,1@1.94,m,1@2.45,m,1@2.45,m,1@2.15,m,1@1.4,m,
 #Basalt (26.52 m or 87 ft) 13 Rows
 1@1.4,m,1@2,m,1@2,m,1@3,m,1@5,m,1@5,m,1@3,m,1@1.57,m,1@1.2,m,1@1,m,1@0.6,m,
 1@0.45,m,1@0.3,m,
 #Alluvium changed from 9 to 5 feet (1.52 m or 5 ft) 4 Rows
 1@0.30,m,1@0.46,m,1@0.46,m,1@0.30,m,
 #Clay Liner (0.91 m or 3 ft) 3 Rows
 1@0.30,m,1@0.31,m,1@0.30,m,
 #Operations Layer (0.91 m or 3 ft) 3 Rows
 1@0.30,m,1@0.31,m,1@0.30,m,
 #Waste (10.40 m or 34 ft adjusted to 12.56 m to account for cube vs
 trapezoid)
 # 11 Rows
 1@0.5,m,1@0.5,m,1@1,m,1@1,m,1@1.64,m,1@1.64,m,1@1.64,m,1@1,m,1@1,m,1
 @1,m,

-Rock/Soil Zonation Card

14,
 #Lower 61 m of Basalt Aquifer
 Basalt Aquifer,1,60,1,1,1,9,
 #Begin First 9 m of Upper 15 m of Basalt Aquifer
 Basalt Aquifer,1,60,1,1,10,15,
 #Upper 6 m of Basalt Aquifer
 Basalt Aquifer,1,60,1,1,16,21,
 #Lowest Vadose Basalt Layer
 Basalt,1,60,1,1,22,28,
 Interbed,1,60,1,1,29,32,
 Basalt,1,60,1,1,33,45,
 Interbed,1,60,1,1,46,49,
 Basalt,1,60,1,1,50,58,
 Interbed,1,60,1,1,59,64,
 Basalt,1,60,1,1,65,77,
 Alluvium,1,60,1,1,78,81,
 Clay,1,60,1,1,82,84,
 Operation Gravelly Sand,1,60,1,1,85,87,
 Waste Gravelly Sand,1,60,1,1,88,98,

-Inactive Nodes Card

#Integer,
 2,
 16,60,1,1,1,98,
 1,15,1,1,1,84,

-Mechanical Properties Card

#Particle density = 2650 kg/m³ except for clay and old alluvium
 #Subgrade, attenuation barrier, and drain rock used in earlier models but
 #not used here
 #Basalt and interbed properties from P. Martian Screening Model
 Basalt Aquifer,,,0.06,0.06,,,Millington and Quirk,
 Interbed,,,0.487,0.487,,,Millington and Quirk,

Basalt,,,0.05,0.05,,,Millington and Quirk,
 #
 #Old Alluvium characteristics from Geotech report measurements
 # sat. moisture content (0.422, 0.426); dry bulk density (1.60, 1.64 g/cm^3)
 # particle density = $1.62 \text{ g/cm}^3 / (1 - 0.424) = 2.8125 \text{ g/cm}^3$
 Alluvium,2812.5,kg/m^3,0.424,0.424,,,Millington and Quirk,
 #Attenuation Barrier,,,0.400,0.400,,,Millington and Quirk,
 #Clay characteristics per discussion with J. Dehner
 Clay,2600,kg/m^3,0.390,0.390,,,Millington and Quirk,
 #Drain Rock,,,0.400,0.400,,,Millington and Quirk,
 Operation Gravelly Sand,,,0.275,0.275,,,Millington and Quirk,
 #Operation Gravelly Sand dry bulk density = 120 lb/ft^3 (per J. Dehner)
 # $120 \text{ lb/ft}^3 * 0.4536 \text{ kg/lb} * 1 \text{ ft}^3 / (0.3048 \text{ m/ft})^3 = 1922.25 \text{ kg/m}^3$
 #Porosity Operation Gravelly Sand = $1 - (1922.25 / 2650) = 0.275$
 Waste Gravelly Sand,,,0.266,0.266,,,Millington and Quirk,
 #Waste Gravelly Sand dry bulk density = 121.5 lb/ft^3 (per J. Dehner)
 # $121.5 \text{ lb/ft}^3 * 0.4536 \text{ kg/lb} * 1 \text{ ft}^3 / (0.3048 \text{ m})^3 = 1946.28 \text{ kg/m}^3$
 #Porosity Waste Gravelly Sand = $1 - (1946.28 / 2650) = 0.266$

~Hydraulic Properties Card

#Properties from P. Martian Screening Model except old alluvium
 Basalt Aquifer,9.00e+01,darcy,,,3.00e-01,darcy,
 Interbed,6.7e-5,hc:cm/s,,,6.7e-5,hc:cm/s,
 Basalt,9.00e+01,darcy,,,3.00e-01,darcy,
 #Old Alluvium characteristics from Geotech report measurements
 # sat. hydraulic conductivity (1.2e-07 cm/s, 6.2e-08 cm/s, 7.1e-08 cm/s)
 Alluvium,1.2e-07,hc:cm/s,,,1.2e-07,hc:cm/s,
 #Subgrade,1e-04,hc:cm/s,,,1e-04,hc:cm/s,
 #Attenuation Barrier,1e-07,hc:cm/s,,,1e-07,hc:cm/s,
 Clay,1e-07,hc:cm/s,,,1e-07,hc:cm/s,
 #Drain Rock,3.0e-01,hc:cm/s,,,3.0e-01,hc:cm/s,
 Operation Gravelly Sand,1e-04,hc:cm/s,,,1e-04,hc:cm/s,
 Waste Gravelly Sand,1e-03,hc:cm/s,,,1e-03,hc:cm/s,

~Saturation Function Card

#Parameters from P. Martian Screening Model except old alluvium
 #alpha, n, theta R, m
 #m only specified for basalts, otherwise default m = 1 - 1/n
 Basalt Aquifer,Nonhysteretic van Genuchten,4.0,1/m,4.5,0.0002,0.7777778,
 Interbed,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.142,,
 Basalt,Nonhysteretic van Genuchten,4.0,1/m,4.5,0.0002,0.7777778,
 #Old Alluvium characteristics from RETC fitting of Geotech report
 measurements
 Alluvium,Nonhysteretic van Genuchten,0.595,1/m,1.09,0.142,,
 #Subgrade,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.142,,
 #Attenuation Barrier,Nonhysteretic van Genuchten,0.800,1/m,1.090,0.07,,
 Clay,Nonhysteretic van Genuchten,0.800,1/m,1.109,0.07,,
 #Drain Rock,Nonhysteretic van Genuchten,493,1/m,2.190,0.005,,
 Operation Gravelly Sand,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.083,,
 Waste Gravelly Sand,Nonhysteretic van Genuchten,1.066,1/m,1.523,0.072,,
 #

~Aqueous Relative Permeability Card

#m only specified for basalts, otherwise default m = 1 - 1/n
 Basalt Aquifer,Mualem,1.9,
 Interbed,Mualem,,
 Basalt,Mualem,1.9,
 Alluvium,Mualem,

```

#Subgrade,Mualem.,
#Attenuation Barrier,Mualem.,
Clay,Mualem.,
#Drain Rock,Mualem.,
Operation Gravelly Sand,Mualem.,
Waste Gravelly Sand,Mualem.,
#
~Solute/Fluid Interactions Card
4,
#H-3,conventional,1.0e-09,m^2/s,noncontinuous...
I-129A,conventional,1.0e-09,m^2/s,noncontinuous...
I-129B,conventional,1.0e-09,m^2/s,noncontinuous...
#U-235,conventional,1.0e-09,m^2/s,noncontinuous...
#Np-237,conventional,1.0e-09,m^2/s,noncontinuous...
Sr-90,conventional,1.0e-09,m^2/s,noncontinuous...
#Zn-65,conventional,1.0e-09,m^2/s,noncontinuous...
Eu-155,conventional,1.0e-09,m^2/s,noncontinuous...
0,
#
~Solute/Porous Media Interaction Card
Basalt Aquifer,6.0,m,3.0,m,
#H-3,0.0,cm^3/g,
I-129A,0.0,cm^3/g,
I-129B,0.0,cm^3/g,
#U-235,0.24,cm^3/g,
#Np-237,0.32,cm^3/g,
Sr-90,0.48,cm^3/g,
#Zn-65,0.64,cm^3/g,
Eu-155,13.6,cm^3/g,
#
Interbed,5.0,m,0,m,
#H-3,0.0,cm^3/g,
I-129A,0.0,cm^3/g,
I-129B,0.1,cm^3/g,
#U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
Sr-90,12.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
Basalt,5.0,m,0,m,
#H-3,0.0,cm^3/g,
I-129A,0.0,cm^3/g,
I-129B,0.0,cm^3/g,
#U-235,0.0,cm^3/g,
#Np-237,0.0,cm^3/g,
Sr-90,0.0,cm^3/g,
#Zn-65,0.0,cm^3/g,
Eu-155,0,cm^3/g,
#
#Subgrade,5.0,m,0,m,
#
Alluvium,5.0,m,0,m,
#H-3,0.0,cm^3/g,
I-129A,0.0,cm^3/g,
I-129B,0.1,cm^3/g,
#U-235,6.0,cm^3/g,

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```

#Np-237,8.0,cm^3/g,
Sr-90,24.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
#Attenuation Barrier,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129A,1.0,cm^3/g,
#I-129B,1.0,cm^3/g,
#U-235,63.0,cm^3/g,
#Np-237,55.0,cm^3/g,
#Sr-90,200.0,cm^3/g,
#Zn-65,2400.0,cm^3/g,
#Eu-155,340,cm^3/g,
#
Clay,5.0,m,0,m,
#H-3,0.0,cm^3/g,
I-129A,1.0,cm^3/g,
I-129B,1.0,cm^3/g,
#U-235,63.0,cm^3/g,
#Np-237,55.0,cm^3/g,
Sr-90,200.0,cm^3/g,
#Zn-65,2400.0,cm^3/g,
Eu-155,340,cm^3/g,
#
#Drain Rock,5.0,m,0,m,
#H-3,0.0,cm^3/g,
#I-129A,0.0,cm^3/g,
#I-129B,0.1,cm^3/g,
#U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
#Sr-90,24.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
#Eu-155,340,cm^3/g,
#
Operation Gravelly Sand,5.0,m,0,m,
#H-3,0.0,cm^3/g,
I-129A,0.0,cm^3/g,
I-129B,0.1,cm^3/g,
#U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
Sr-90,12.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
Waste Gravelly Sand,5.0,m,0,m,
#H-3,0.0,cm^3/g,
I-129A,0.1,cm^3/g,
I-129B,0.1,cm^3/g,
#U-235,6.0,cm^3/g,
#Np-237,8.0,cm^3/g,
Sr-90,12.0,cm^3/g,
#Zn-65,16.0,cm^3/g,
Eu-155,340,cm^3/g,
#
~Initial Conditions Card
Gas Pressure,Aqueous Pressure,

```

```

9,
Aqueous Pressure,,,,,,1,60,1,1,1,98,
#Solute Volume Overwrite,H-3,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,I-129A,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,I-129B,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,U-235,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,Np-237,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Sr-90,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
#Solute Volume Overwrite,Zn-65,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
Solute Volume Overwrite,Eu-155,0.0,1/m^3,0,,0,,1,60,1,1,1,98,
#
#Solute Volume Overwrite,H-3,1946.28,1/m^3,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,I-129A,1946.28,1/m^3,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,I-129B,1946.28,1/m^3,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,U-235,1946.28,1/m^3,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,Np-237,1946.28,1/m^3,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Sr-90,1946.28,1/m^3,0,,0,,1,15,1,1,88,98,
#Solute Volume Overwrite,Zn-65,1946.28,1/m^3,0,,0,,1,15,1,1,88,98,
Solute Volume Overwrite,Eu-155,1946.28,1/m^3,0,,0,,1,15,1,1,88,98,

~Boundary Conditions Card
3,
#
top,neumann,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,inflow aqueous,
#0.0001 m/yr * 1.74 ICDF Recharge Ratio = 0.000174 m/yr
1,15,1,1,98,98,1,
0,day,-0.000174,m/yr,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,
#0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,0,1/m^3,
#
east,seepage face,outflow,outflow,outflow,outflow,
#Emplace seepage face to account for leachate drain removal
#Base of seepage face cell (Height = 0.3 m) set to atmospheric pressure
#P = 101325 - 0.15 m * 9793.52 = 99855.97
15,15,1,1,85,85,1,
0,day,99855.97,Pa,.....#
#
west,seepage face,outflow,outflow,outflow,outflow,
#Emplace seepage face to account for leachate drain removal
#Base of seepage face cell (Height = 0.3 m) set to atmospheric pressure
#P = 101325 - 0.15 m * 9793.52 = 99855.97
1,1,1,1,85,85,1,
0,day,99855.97,Pa,.....#
#
~Surface Flux Card
15,
Aqueous Volumetric Flux,m^3/yr,m^3,top,1,15,1,1,85,85,
#Solute Flux,H-3,1/yr,,top,1,15,1,1,85,85,
Solute Flux,I-129A,1/yr,,top,1,15,1,1,85,85,
Solute Flux,I-129B,1/yr,,top,1,15,1,1,85,85,
#Solute Flux,U-235,1/yr,,top,1,15,1,1,85,85,
#Solute Flux,Np-237,1/yr,,top,1,15,1,1,85,85,
Solute Flux,Sr-90,1/yr,,top,1,15,1,1,85,85,
#Solute Flux,Zn-65,1/yr,,top,1,15,1,1,85,85,

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Solute Flux,Eu-155,1/yr,,top,1,15,1,1,85,85,

Aqueous Volumetric Flux,m^3/yr,m^3,west,1,1,1,1,85,85,
Solute Flux,I-129A,1/yr,,west,1,1,1,1,85,85,
Solute Flux,I-129B,1/yr,,west,1,1,1,1,85,85,
Solute Flux,Sr-90,1/yr,,west,1,1,1,1,85,85,
Solute Flux,Eu-155,1/yr,,west,1,1,1,1,85,85,

Aqueous Volumetric Flux,m^3/yr,m^3,east,15,15,1,1,85,85,
Solute Flux,I-129A,1/yr,,east,15,15,1,1,85,85,
Solute Flux,I-129B,1/yr,,east,15,15,1,1,85,85,
Solute Flux,Sr-90,1/yr,,east,15,15,1,1,85,85,
Solute Flux,Eu-155,1/yr,,east,15,15,1,1,85,85,

~Output Control Card
12,
1,1,85,
5,1,85,
10,1,85,
15,1,85,
1,1,88,
5,1,88,
10,1,88,
15,1,88,
1,1,98,
5,1,98,
10,1,98,
15,1,98,
1,1,yr,m,8,8,8,
8,
aqueous saturation,,
aqueous pressure,Pa,
aqueous moisture content,,
znc aqueous vol,m/yr,
solute aqueous concentration,I-129A,,
solute aqueous concentration,I-129B,,
solute aqueous concentration,Sr-90,,
solute aqueous concentration,Eu-155,,
30,
1,yr,
2,yr,
3,yr,
4,yr,
5,yr,
6,yr,
7,yr,
8,yr,
9,yr,
10,yr,
11,yr,
12,yr,
13,yr,
14,yr,
15,yr,
16,yr,
17,yr,
18,yr,

19, yr,
20, yr,
21, yr,
22, yr,
23, yr,
24, yr,
25, yr,
26, yr,
27, yr,
28, yr,
29, yr,
30, yr,
8,
aqueous saturation,,
aqueous pressure, Pa,
aqueous moisture content,,
znc aqueous vol, m/yr,
solute aqueous concentration, I-129A,,
solute aqueous concentration, I-129B,,
solute aqueous concentration, Sr-90,,
solute aqueous concentration, Eu-155,,
rock/soil type,,